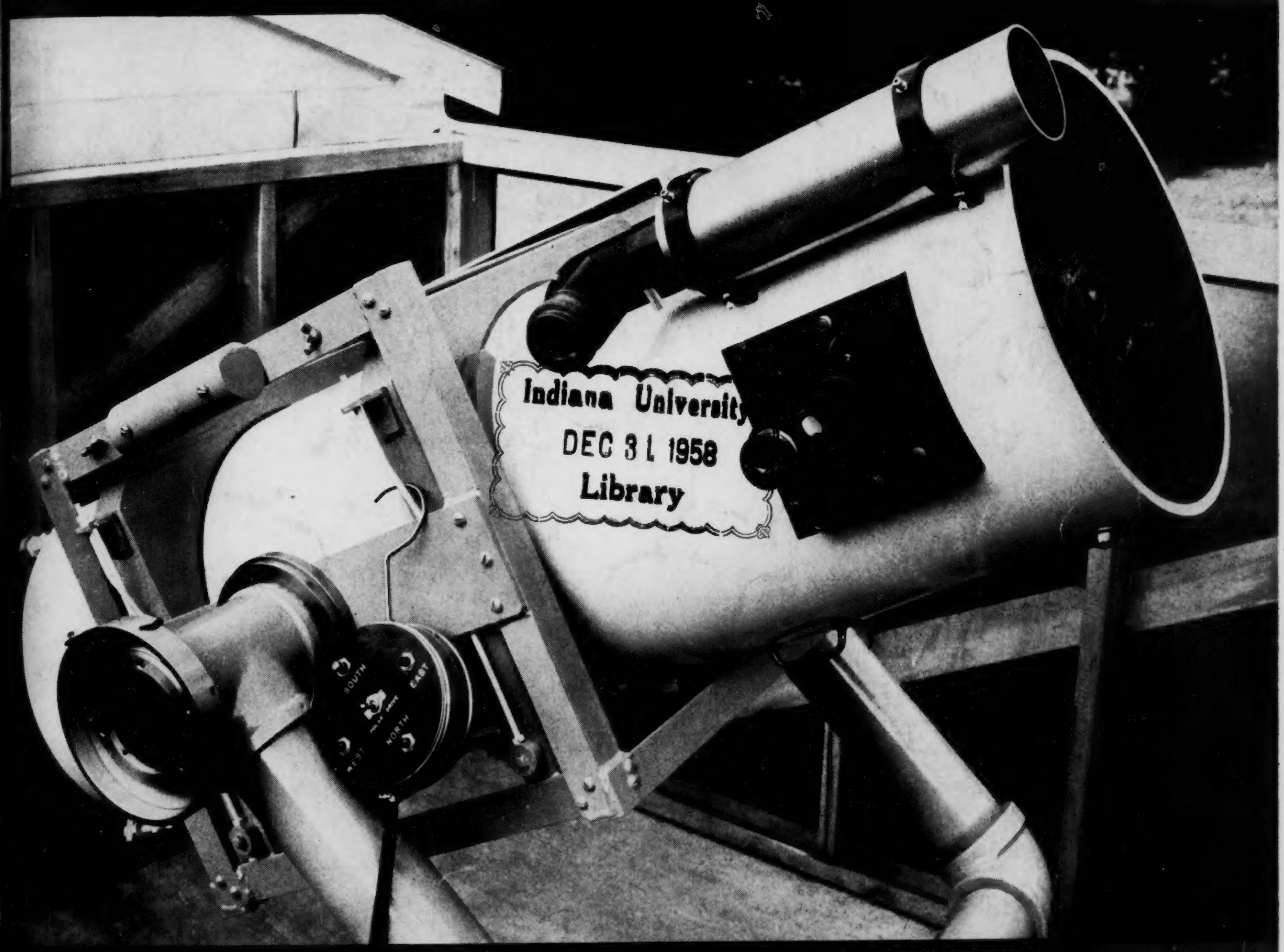


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Sky and TELESCOPE

CHARLES A. FEDERER, JR., *Editor*

JOSEPH ASHBROOK, *Technical Editor*

Vol. XVIII, No. 3 JANUARY, 1959

CONTENTS

COVER: George T. Keene, of Rochester, New York, built this neat-looking 12-inch reflecting telescope for about $60 in two years' spare time. Its small focal ratio, f/4.3, makes it a very effective instrument for photographing nebulae. (See page 134.)

SKY AND TELESCOPE is published monthly by Sky Publishing Corporation, Harvard College Observatory, 60 Garden St., Cambridge 38, Mass. Second-class postage paid at Boston, Mass.

Subscription: $5.00 per year in the United States and possessions; $9.00 for two years; $13.00 for three years. Add $1.00 per year for Canada, Mexico, and all countries of the Pan American Postal Union, making the total subscription $6.00 for one year; $11.00 for two years; $16.00 for three years. Add $2.00 per year for all other foreign countries, making the total subscription $7.00 for one year; $13.00 for two years; $19.00 for three years. Canadian and foreign remittances should be made in United States currency. Single copy 50 cents. Back numbers, as available, 50 cents each.

All notices of change of address must be sent one month in advance and accompanied by old and new addresses. When sending your renewal order, or writing in regard to your subscription, your current mailing address must be given. Please return our bill form with your renewal payment. Circulation staff: Nancy R. Bolton, manager; John Simmons; Helen B. Sniegiecki; Stacia Strong.

Editorial and advertising offices: Harvard College Observatory, Cambridge 38, Mass. Advertising manager, Henry M. Corrado. Advertising rates are listed in STANDARD RATE AND DATA SERVICE, or sent upon request.

Unsolicited articles and pictures are welcome, bearing adequate return postage, but we cannot guarantee prompt editorial attention, nor are we responsible for the return of unsolicited material. Editorial assistants: Virginia K. Cox; Elizabeth C. Merrylees; William E. Shawcross. The principal articles are indexed in THE READERS' GUIDE TO PERIODICAL LITERATURE.

Volcanic Activity on the Moon?

WIDE INTEREST was aroused by the report that the Soviet astronomer N. A. Kozyrev observed a volcanic eruption in the lunar crater Alphonsus, on the morning of November 4, 1958. The evidence is much more definite than in many past claims of observed changes on the moon.

Dr. Kozyrev is a professional astronomer, who has been making a spectroscopic study of luminescence of the lunar surface, using the 50-inch reflector of the Crimean Astrophysical Observatory. His first-hand statement of his finding has not yet become available. The essential facts, however, were ascertained by Zdenek Kopal, University of Manchester, England, from a long-distance telephone conversation with A. A. Mikhailov, director of Poulkovo Observatory, of which the Crimean station is a branch.

Dr. Kopal reported the story in the *New Scientist* for November 27, 1958. On the night of November 3-4, Dr. Kozyrev was taking a series of spectra of the Alphonsus central peak, shortly before the sun set on that part of the moon. The spectrograms had a dispersion of 50 angstroms per millimeter, and the exposure times were each 30 minutes.

Between 3:00 and 3:30 UT, while guiding, Dr. Kozyrev noticed that the outlines of the central peak became blurred and appeared engulfed in a reddish cloud, which gradually shifted about two seconds of arc in the direction of the setting sun. This visual phenomenon was apparently short-lived.

When the spectrograms were developed, the one exposed between 2:30 and 3:00 UT showed the violet part of the spectrum greatly weakened. The spectrogram of 3:00 to 3:30, when the red cloud was seen, showed *emission* bands of diatomic carbon (Swan bands of C_2) in the part where the spectrograph slit cut the central mountain. By far the most intense of the series was the band at 4737 angstrom units. As Dr. Mikhailov remarked to Dr. Kopal, the spectrum of the central mountain at that time was strikingly like that of the head of a comet. There was no trace of the bands on the spectrogram taken immediately afterward.

At other observatories, subsequent examination of Alphonsus was not possible until two weeks later, when sunrise took place on this region of the moon. G. P. Kuiper, of Yerkes and McDonald Observatories, telegraphed to Harvard: "Observed lunar crater Alphonsus November 19 with 82-inch visually. No changes

(Continued on page 131)

Classifying the Galaxies

OTTO STRUVE
Leuschner Observatory
University of California

Like M33 on the facing page, this spiral galaxy in Virgo, NGC 5364, is Sc on the Hubble system. In the new Morgan classification it is of an intermediate type, fgS4. This is a 200-inch telescope photograph.

LESS than six months before he died, Edwin P. Hubble traveled from Mount Wilson and Palomar Observatories to England, where on May 8, 1953, he presented the annual Darwin lecture to the Royal Astronomical Society. The California astronomer concluded his discussion, "The Red Shifts of the Galaxies," with these words:

"As for the future, it is possible to penetrate still deeper into space — to follow the red shifts still farther back in time — but we are already in the region of diminishing returns; instruments will be increasingly expensive, and progress increasingly slow. The most promising programs for the immediate future accept the observable region as presently defined, hope for only modest extensions in space, but concentrate on increased precision and reliability in the recorded description. The reconnaissance is being followed by an accurate survey; the explorations are pushed toward the next decimal place instead of the next cipher. This procedure promises to reduce the array of possible worlds as surely as did the early rapid inspections of the new territory. And later perhaps, in a happier generation, when the cost of a battleship can safely be diverted from insurance of survival to the consolations of philosophy, the march outward may be resumed.

". . . From our home on the earth, we look out into the distances and strive to imagine the sort of world into which we are born. Today we have reached far out into space. Our immediate neighborhood we know rather intimately. But with increasing distance our knowledge fades, and fades rapidly, until at the last dim horizon we search among ghostly errors of observations for landmarks that are scarcely more substantial. The search will continue. The urge is older than history. It is not satisfied and it will not be suppressed."

During the five years since Hubble made this appraisal, our knowledge of galaxies has advanced considerably. A. R. Sandage and others have made important observations of the red shifts in the spectra of distant galaxies, while Walter Baade has given us a more reliable distance scale than we had, and R. Minkowski has studied colliding stellar systems and their strong emission of radio waves. Recently, F. Zwicky has published in *L'Astronomie* (July-August, 1958) some startling results on the spectra of luminous "bridges" between neighboring stellar systems. But perhaps the most far-reaching study is that by W. W. Morgan and N. U. Mayall, who have uncovered the relationship between the form of a galaxy and the kinds of stars of which it is composed.

It is only since the construction of the large reflecting telescopes at Mount Wilson Observatory that our ideas about galaxies have been clarified. Visual observations could not give their true nature, but during the first part of the 20th century long-exposure photographs resolved into stars the outer parts of the nearest spiral nebula — M31 in Andromeda — showing that object to be a counterpart of our Milky Way system.

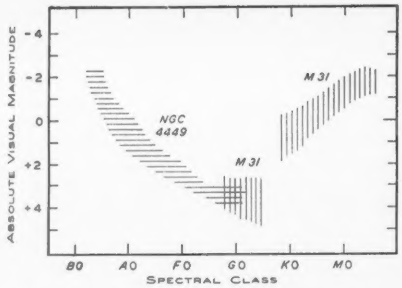
Because some of these stars in M31 turned out to be Cepheid variables, the distance to the Andromeda galaxy could be determined. In 1929 Hubble found that M31 Cepheids are about 4.6 magnitudes fainter than those Cepheids of the same period in the Small Magellanic Cloud. This placed M31 at 8.3 times the distance of the Small Cloud. The latter is some six degrees across, while the main

FACING PICTURE: The spiral galaxy in Triangulum, Messier 33 or NGC 598, one of the Milky Way's nearest neighbors, photographed in red light with the 48-inch Schmidt telescope on Palomar Mountain. Classified Sc by E. P. Hubble, M33 is of intermediate type in the new system of W. W. Morgan, who calls it fS3. Unless otherwise indicated, all photographs with this article are from Mount Wilson and Palomar Observatories.

part of M31 is about $3\frac{1}{2}$ degrees. Thus, if we could bring M31 as near to us as the Small Cloud, it would be $8.3 \times 3\frac{1}{2}$ or about 30 degrees in diameter — large enough to cover the Big Dipper. Evidently, the Small Cloud is actually much smaller than the Andromeda system.

A few years ago in South Africa, A. D. Thackeray discovered numbers of cluster-type variables in the Small Magellanic Cloud. These rapidly pulsating stars have apparent magnitudes around 19.0, corresponding, after allowance for the dimming by interstellar dust, to a distance of about 50,000 parsecs or roughly 160,000 light-years. This is five or six times the distance of the sun from the galactic center; consequently, the Magellanic Clouds are independent galaxies, not merely condensations of the Milky Way. And M31, now considered about 10 times as distant as the Magellanic Clouds, must indeed be another system of stars like our own and slightly larger.

These two spirals are very similar, not only in size but in content. Both contain dark areas of absorbing material between the stars, emission nebulae, globular and open star clusters, and variable stars including novae and supernovae.



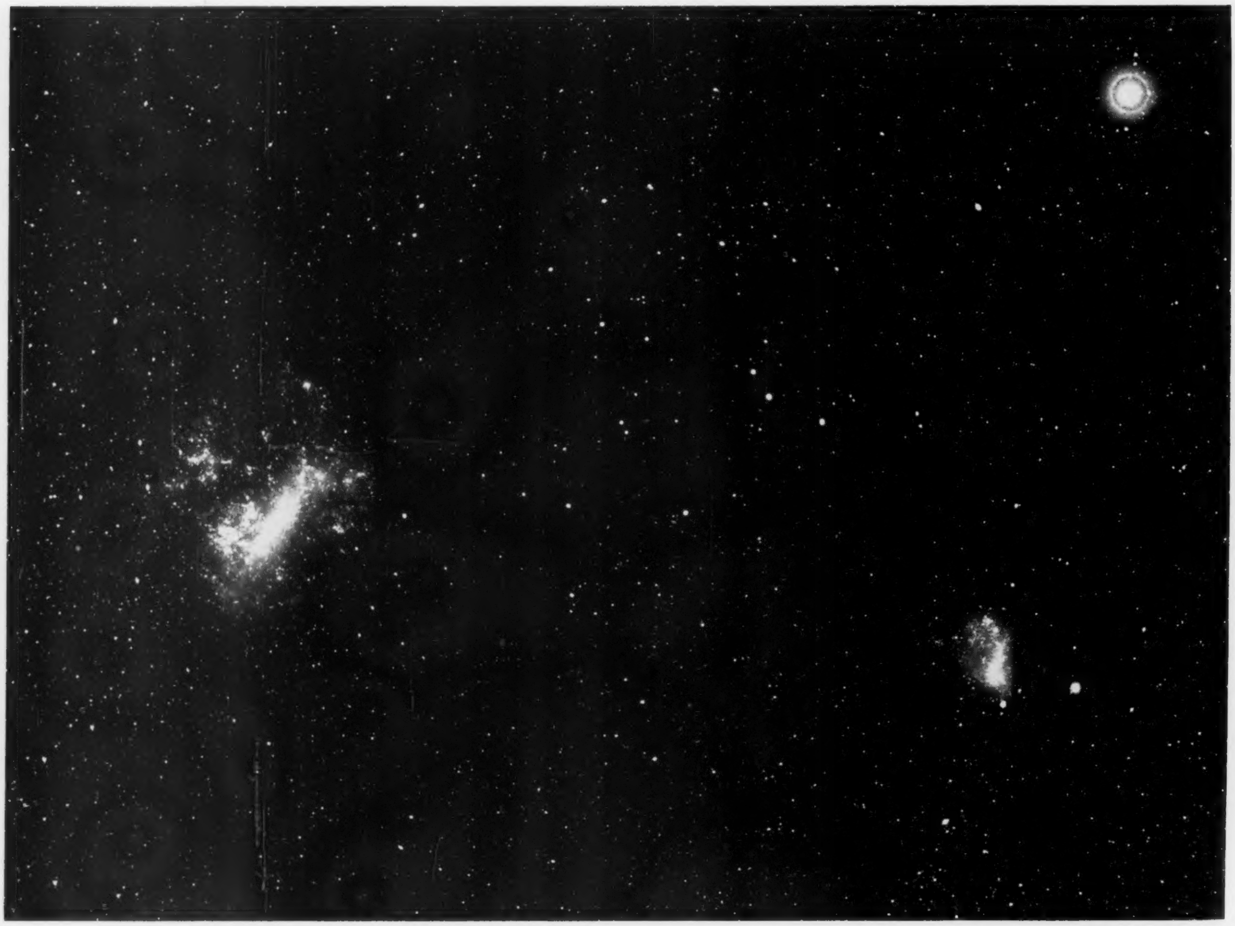
In August, 1957, W. W. Morgan and N. U. Mayall published this hypothetical diagram comparing the stellar contents of M31 (vertical lines) and NGC 4449 (horizontal lines). The first is type kS5, the second aI, in the new Morgan classification. From "Publications" of the Astronomical Society of the Pacific.

Moreover, M31 is also rotating around an axis at right angles to its plane of symmetry. But our system and M31 are types of galaxies that differ greatly in size and shape from the Magellanic Clouds.

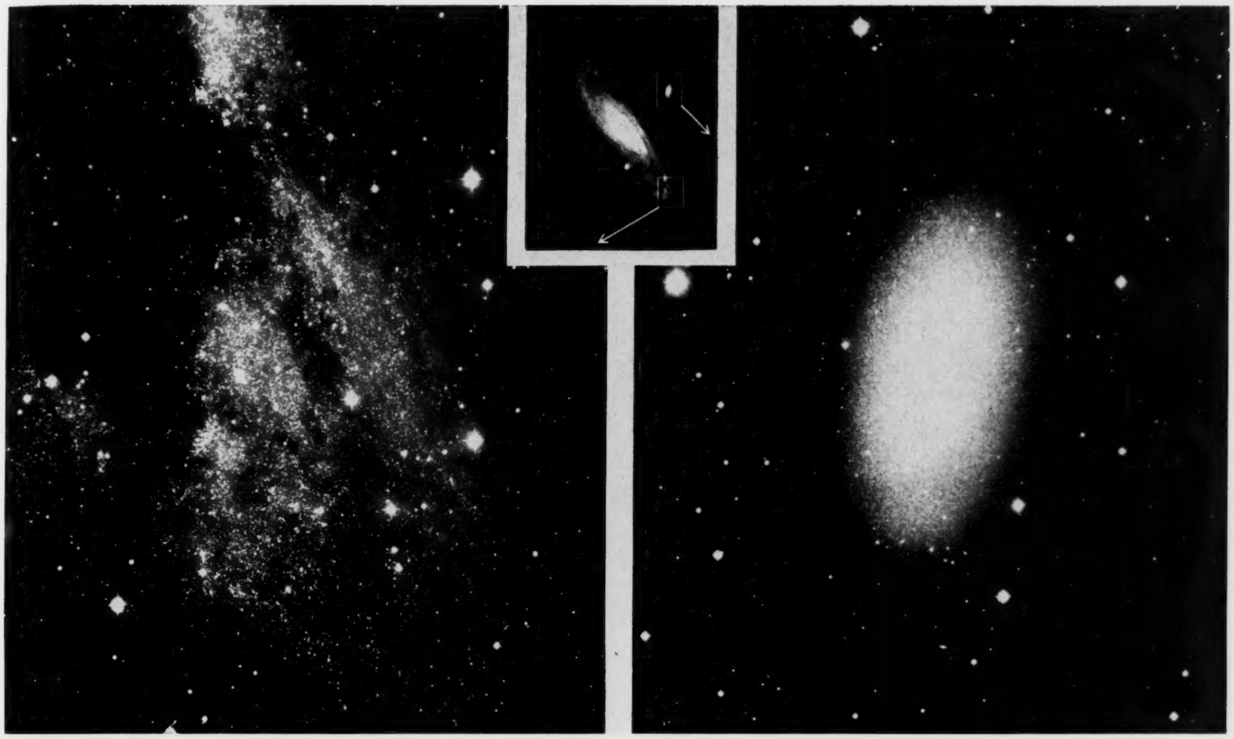
The classification of galaxies was attempted many years ago by Hubble, who recognized three basic varieties: S, spiral; I, irregular; and E, elliptical. Among the spirals two main groups are distinguished — normal and barred. Each of these is subdivided into three classes, a, b, and c, depending partly upon the amount of material in the arms relative to that in the nuclear region, and partly upon the degree of openness of the arms and their resolution into stars. M31 and our Milky Way galaxy are both of type Sb, whereas the Magellanic Clouds are called irregular (though thought by some to be barred spirals).

The arms of all spirals contain highly luminous *O* and *B* stars, as well as dust and gas. Baade believes that if dust and gas were lacking during the formation of a galaxy, spiral arms would not develop. Therefore, spiral arms seem to require the presence of dust and gas. But if the latter material were removed after the arms had formed (for instance, by collision with another galaxy), the spiral form would be preserved but the galaxy would then consist of stars only.

Irregular galaxies, typified by the Magellanic Clouds, lack a central nucleus and a plane of rotational symmetry. Hubble estimated that one galaxy in four is an irregular. In the Large Cloud blue stars and red supergiants are present, as well



The Large Magellanic Cloud, one of our two bright irregular galaxy neighbors, is at the left in this Harvard Observatory photograph, which includes the Small Cloud (lower right) and the bright star Achernar (upper right).



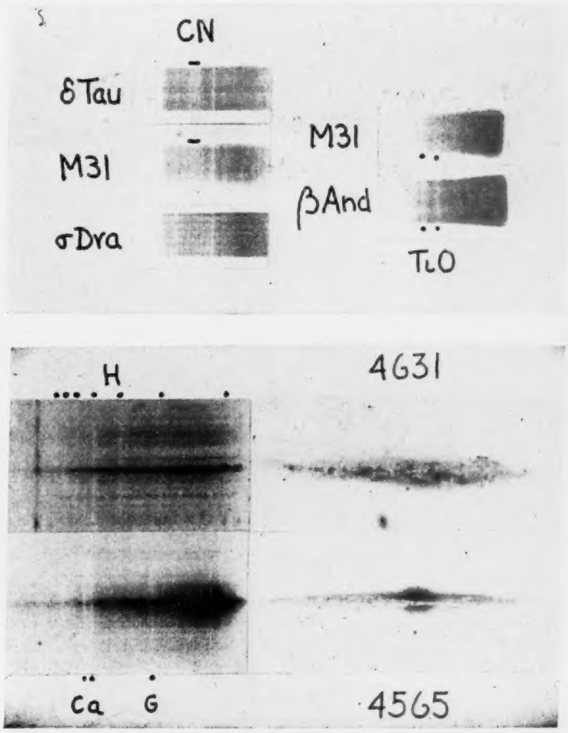
These 200-inch photographs from Mount Wilson and Palomar Observatories reveal the differing stellar contents of the arms of the Andromeda nebula and its spheroidal companion, NGC 205. The inset shows their respective locations with reference to the main body of M31. In the left-hand picture, giant and supergiant stars of Population I show up well in a blue-light photograph. Between the arms are Population-II stars, but these are relatively faint and unresolved, appearing as a hazy patch in the upper left part of the field. In a yellow-light photograph (right) NGC 205 is composed mainly of Population-II stars, of which the brightest are red and 100 times fainter than blue supergiants of Population I.

as obscuring dust which blots out background galaxies. Both Clouds contain much neutral hydrogen gas, as Australian radio observations have shown. There are also several thousand typical Cepheid variable stars. All of these features are found in the spiral arms of the Milky Way and of M31, and are representative of what Baade many years ago named Population I.

But the Large Cloud contains several globular clusters, in at least one of which are cluster-type variables of Baade's Population II. Hence, although the Large Cloud is mostly of Population I, it has a small admixture of Population II. The Small Cloud, however, is almost free of obscuring dust, for distant galaxies can be seen through it, undimmed. This suggests that it is richer in Population-II objects than is the Large Cloud, but it does have a few hydrogen emission nebulae, characteristic of Population I.

Elliptical galaxies have a distinctive property. The shape of any one of them remains unchanged in a series of photographs taken with longer and longer exposure times. More stars in the outermost regions are recorded, but the curves of equal star density retain the elliptical contour shown on short exposures. Ellipticals are basically of Population II.

One well-known system of this kind is NGC 205, a companion of the Andromeda galaxy. Long-exposure photographs resolve it into stars, the brightest of which are red giants. Baade has found in this system two absorption patches indicating dust, and a dozen luminous *B*-type stars.



From the Morgan-Mayall paper of August, 1957, these plates illustrate the galaxy characteristics that lead to the new classification. Above: The central portion of M31 has a strong cyanogen band near 4200 angstroms, like that of the K0 giant star Delta Tauri, but this band is weak or absent in the K0 dwarf Sigma Draconis. The galaxy also has titanium oxide bands at 5900 and 6200 angstroms, like those of the red giant Beta Andromedae. Below: A galaxy of weak central concentration, NGC 4631, has hydrogen absorption lines (marked H) like those of an early-type star, and is an "af" system. The strongly nucleated spiral, NGC 4565, however, has intense lines of ionized calcium like those in late-type stars. Engravings from Astronomical Society of the Pacific.

Except for these impurities, the predominant stellar objects in NGC 205 are of Population II.

Photoelectric measurement of the col-

Group "a" includes galaxies with little or no central concentration of light (on pictures less strongly exposed than this one by the 200-inch telescope). This spiral galaxy in Camelopardalis, NGC 2403, is designated aS4 by Morgan, its inclination to the plane of the sky being moderate (4).

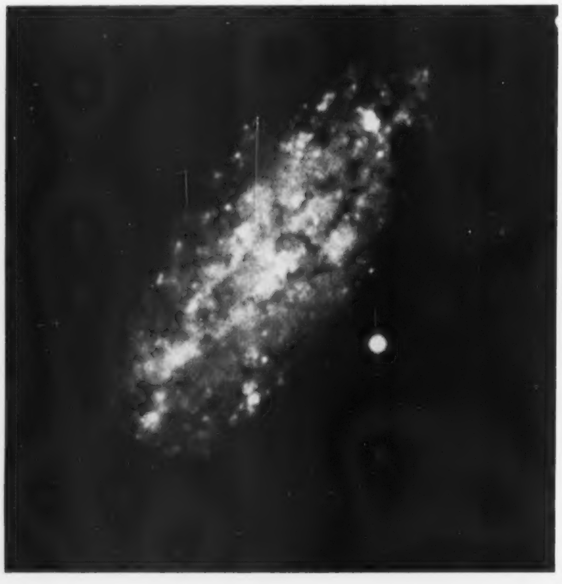
ors of various classes of galaxies gives a clue to their contents. J. Stebbins and A. E. Whitford have made extensive observations of this kind. Baade points out that the observed color indices are grouped around two values. The E, Sa, and Sb galaxies all have colors around +0.87 (if we consider only the central regions of the Sb objects), about the color of a star of spectral type *G*. The very open Sc spirals are not so red, with colors around +0.45, like those of *F*-type stars, extensive photoelectric data show.

These colors are strongly influenced by those of the brightest stars in each galaxy. Thus, if a system contains many red giants and relatively few main-sequence *O* and *B* stars, it will appear redder than one whose brightest members are early-type main-sequence stars.

We can further analyze the contents of a galaxy by means of its spectrum. For all but the very nearest systems, however, the spectrum is of the integrated light — the combined radiation from all the stars and other objects in the galaxy. Morgan and Mayall have recently explored the possibility of using certain dominant spectral features as indicators of the approximate form of the spectrum-luminosity diagram of a galaxy's stars.

For instance, as shown by their spectra on page 127, they have found that the Sb spirals (such as M31) have absorption lines which suggest that the relative number of dwarf stars of spectral type *K* to giants of this type is no greater than 50 to one. Thus, the giants are relatively abundant, as they are in the neighborhood of the sun, where the ratio is 40 to one. These *K* giants are so luminous that they tend to dominate the spectrum in certain regions.

Morgan and Mayall note that Sc spirals and irregular galaxies have spectra showing strong absorption lines of hydrogen. Irregular systems probably contain many main-sequence stars of types *B, A,* and *F;* their H-R diagrams might resemble that of a young star cluster. The Sc spirals also show indications of a well-populated main sequence, as is suggested by their colors. The Sb and Sa spirals, on the other hand, have spectra indicative of many cool giants and few main-sequence objects; their H-R diagrams might be like those of the older galactic clusters. Finally, the composition of the elliptical galaxies bears a strong resemblance to that of globular clusters.



Only 22 degrees from the north celestial pole is this compact irregular galaxy, NGC 2976, one of the striking group in Ursa Major that includes M81 and M82. This 200-inch photograph reveals complex knots of stars and obscuring patches, although the over-all intensity is rather smooth. On the new Morgan system the galaxy is classified aI, a very early-type irregular system.

This is a 200-inch picture of a large barred spiral in Eridanus, NGC 1300, which was designated SBb by Hubble. Its predominantly intermediate stellar population is indicated by Morgan's classification of fB2.

These correspondences suggest that the evolution of the galaxies reflects the development of the stars they contain. Thus, elliptical galaxies would be the oldest and the irregular galaxies the youngest, in an evolutionary sense. As with the stars themselves, however, the evolutionary age may not be the same as the chronological age.

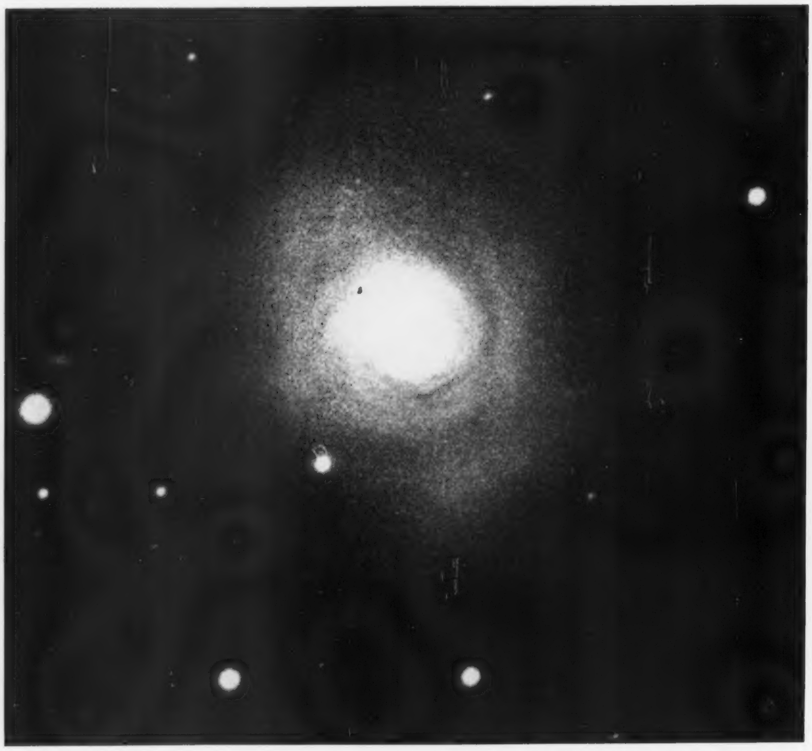
Morgan has proceeded further, and has devised a new system of classifying galaxies, in which the class as estimated from the form of a galaxy also indicates its spectral properties. In establishing this system, the Yerkes Observatory astronomer had the aid of the remarkable collection of galaxy photographs taken by Hubble with the 100-inch and 200-inch telescopes.

There are two extremes in the new Morgan classification. One is represented by certain spirals with little or no central condensation of luminosity, and by irregular systems like the Magellanic Clouds, for the composite spectra of these galaxies show that they are rich in stars of spectral types *B, A,* and *F.* These Morgan calls "a" galaxies. At the other extreme are the giant elliptical objects, such as those in the Virgo group and spirals like M31. Their luminosity comes mainly from a bright central region, and they have spectra indicating that late-type stars of spectral type *K* are dominant. Such systems are classed as "k."

Intermediate between these extremes are "af," "f," "fg," "g," and "gk" galaxies, these letters being in the same order as the *A, F, G, K* of the sequence of stellar spectra. The principal criterion is the extent to which brightness is concentrated in the central region of the galaxy, "k" objects having high concentration and "a" ones very little. The luminosity of the brighter parts of "k" systems is due principally to yellow giant stars, whereas in the "a" galaxies the early-type stars have a pronounced effect on the spectrum in the blue and violet regions.

To the fundamental characteristic just described, Morgan appends letters for

A fine 60-inch reflector photograph of the field of NGC 7331 in Pegasus was made on August 28, 1916, with a 6¼-hour exposure. The spiral galaxy is classified as gkS5 by Morgan, and as Sb in the Hubble system.



A striking galaxy with a strong central concentration of brightness is NGC 2681, in Ursa Major, from a photograph with the 200-inch Hale telescope. Morgan classifies it kS1, whereas Hubble had called it Sa.

the form: S, spiral; B, barred spiral; E, elliptical; I, irregular (following the classical Hubble system for these four); Ep, elliptical with well-marked dust absorption; D, rotational symmetry without pronounced spiral or elliptical structure; L, low surface brightness; and N, systems having small brilliant nuclei superimposed on a much fainter background.

Lastly, a number from one to seven can be added, one indicating a galaxy seen full face (at right angles to its principal plane), seven an edgewise system (its principal plane in the line of sight). Unlike the other two parameters, this one depends solely on the angle of view, and is not an intrinsic property of the object.

Full details of the new system are presented by Morgan in last August's issue of the *Publications* of the Astronomical Society of the Pacific, together with 76 photographs of galaxies and a catalogue of 608 objects with their new typings.

For example, the Whirlpool nebula in Canes Venatici, M51, is called fS1 on the Morgan system. The older Hubble classification was Sc, that of a fairly open spiral. NGC 221, another companion of the great Andromeda nebula, is called kE3, in place of Hubble's E2. M31 itself is kS5.

Among the immediate results arising from Morgan's work is the remarkable fact that the different galaxy types are not well mixed over all parts of the sky. He writes:

"In the area from 10 hours to 12 hours of right ascension and between declinations +30° and +60°, the number of 'a' systems among the nearer galaxies is outstanding. Perhaps the most interesting comparison is between the brightest members of the Ursa Major and Virgo clouds; the former contains a large percentage of 'a' and 'f' systems, and few – if any, ellipticals; the ratio of 'a' + 'af' systems to 'k' systems is quite different in the two clusterings."

Is this nonuniformity due to chance? Or does it signify a fantastic difference in chemical composition (or other characteristics affecting evolution) of different parts of the original intergalactic material? Morgan carefully refrains from commenting on his remarkable discovery.

In his latest contribution, at the Berkeley meeting of the National Academy of Sciences, on November 6, 1958, Morgan demonstrated several low-dispersion spectra of the integrated light of a "transparent" spot near the central nucleus of the Milky Way. This area is free from intervening dust clouds, so the integrated light appears to come from stars closely associated with the nucleus. The spectrum indicates the principal contributors to the light to be dwarf stars of solar type, quite different from those of globular clusters associated with our galaxy. In the central nucleus of the Andromeda system, on the other hand, the principal contributors appear to be *K* and *M* giants that resemble the stars of globular clusters.

Then Morgan discussed a small area of the Milky Way which is heavily obscured by dark clouds lying between us and the galactic center, so that only nearby stars can be seen. In this case, the integrated spectrum resembled types *A* or *F*. Thus, the disk population of the Milky Way may contain more early-type stars than the central nucleus. In other words, the disk composition may be like that of the arms – Baade's Population I – rather than that of the nucleus. The spiral arms between us and the center probably contribute very little to the integrated light of the heavily obscured spot that Morgan observed.

EDITOR'S NOTE: With the publisher's permission, portions of this article have been adapted from a chapter in the forthcoming textbook, *Elementary Astronomy*, by O. Struve, B. Lynds, and H. Pillans, copyright, 1959, Oxford University Press, Inc.

Messier 104, the famous Sombrero nebula in Virgo (NGC 4594), is a nearly edgewise spiral with a strong lane of obscuring matter in its equatorial plane. At the left, the longer exposure of these 60-inch Mount Wilson reflector photographs reveals the spiral structure, while the short exposure at the right shows a small, bright nucleus. The Morgan classification is therefore kS6p, p standing for peculiar or abnormal.

NEWS NOTES

HEIGHTS OF METEORS

A study of the heights of meteors observed visually, photographically, and by radio methods has been made by **D. W. R. McKinley** and **Peter M. Millman** at the National Research Council of Canada. They find that all meteors tend to become observable at approximately the same height, about 100 kilometers (62½ miles), regardless of their intrinsic luminosities. The end heights are, however, considerably lower for the brighter objects, which are more massive and take longer to burn out.

The accompanying chart is adapted from one in the October, 1958, *Journal* of the Royal Astronomical Society of Canada. It incorporates visual observations made by the Harvard Observatory expedition to Arizona in 1931-1932, data from three Harvard photographic programs, and recent unpublished observations by Drs. McKinley and Millman using a three-station radar network. The observed brightness of each meteor was converted to absolute magnitude — defined as the apparent magnitude the meteor would have if at a height of 100 kilometers and in the zenith of the observer.

A total of 2,830 meteors contributed to the curves showing beginning- and end-point heights for visual meteors. These seem systematically low when compared with those observed by other methods.

The photographic data include 217 meteors recorded by small patrol cameras and 621 super-Schmidt camera photographs. The heights for each meteor were individually corrected for systematic velocity effects and reduced to values corresponding to a standard geocentric velocity of 45 kilometers per second.

This was also done for the 645 meteors represented by the nearly horizontal radio curve, which shows the average height of the long-enduring portion of each radar echo. The vertical lines are averages for the beginning and end heights of 76 very short echos, of the type sometimes called the "head echo."

FURTHER WORD ON LAST OCTOBER'S ECLIPSE

All of the Nike-Asp rockets launched by the Naval Research Laboratory during the total solar eclipse last October 12th (page 68, December issue) radioed information back to the instrument station for about eight minutes during their flights. The rockets were fired from the deck of the USS *Point Defiance,* which was at the Danger Islands in the South Pacific, and at least two of them reached 150 miles altitude.

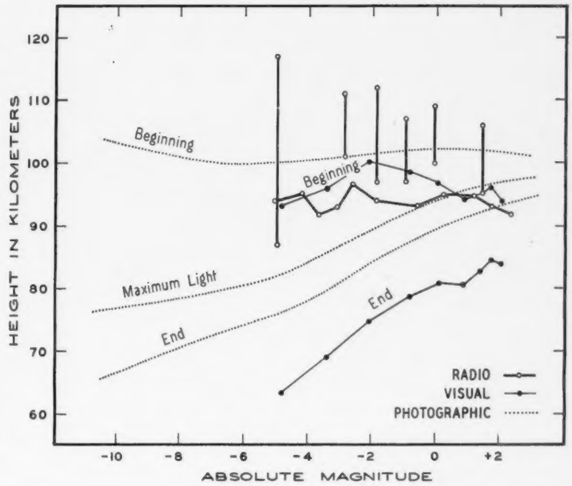
Another valuable ascent was made the following day when there was an unusually large solar flare. Fortunately, there was one remaining rocket, and it was immediately fired to take advantage of the opportunity.

From Rarotonga, Cook Islands, Frank M. Bateson has written that clouds prevented any observation of the first contact during the partial eclipse there. However, the average from four observers for the moment of last contact was $21^h\ 37^m\ 7^s.12$ Universal time. The Bateson party also secured an 8-mm. motion picture of mid-eclipse, when the sun was approximately 85-per-cent covered. The other observers in the group were Mrs. Bateson, A. A. Bailey, and D. Berry.

IN THE CURRENT JOURNALS

STELLAR POPULATIONS, by Margaret and Geoffrey Burbidge, *Scientific American,* November, 1958. "After 15 years of investigation our picture of stellar populations has grown less simple and perhaps less surprising. Instead of supposing that all stars fall into just two groups, widely separated in age and location in the galaxies, we now believe that there is a more nearly continuous spectrum of ages, from very ancient stars to those still in the process of birth."

The relation between the heights and intrinsic brightnesses of meteors is plotted here by Peter M. Millman. The horizontal scale indicates the magnitude the meteor would have if photographed from 100 kilometers. The more luminous the meteor, the deeper it plunges into the atmosphere before vanishing, but the three different methods of observation — visual, photographic, and radar — give somewhat different results. From the "Journal" of the Royal Astronomical Society of Canada.



VOLCANIC ACTIVITY ON THE MOON?

(Continued from page 123)

visible compared to earlier high-quality photographs. Central peak is smooth and white as before without evidence of crater or lava flows."

Another experienced lunar observer who did not find evidence of change was Walter H. Haas, Las Cruces, New Mexico, with a 12½-inch reflector. Mr. Haas writes that he watched on November 19th from 3:20 UT, when only the central peak caught the sunlight, to 5:20 when about one-third of the floor of Alphonsus was still shadowed. "Nothing unusual or not in agreement with photographs was observed."

Further inspection by Mr. Haas on November 20th, 24th, and 25th showed no signs of change in Alphonsus, nor did a scrutiny on December 3rd under a very low evening illumination. All these surveys were made with magnifications of 303 or 367.

According to newspaper accounts, H. P. Wilkins of Bexleyheath, England, examined Alphonsus on November 19th with his 15-inch reflector, and saw a reddish patch about 1½ miles across, covering an area normally occupied by two small pits on the southern slope of the central peak.

In his article, Dr. Kopal points out that the phenomenon observed by Dr. Kozyrev may result from the release of a large puff of gas from the lunar surface. It was luminous either from its own heat or from stimulation by solar ultraviolet radiation. Such an outrush of gas could carry aloft dust particles from the lunar surface, which may account for the dimming of the peak's light at short wave lengths in the first spectrogram of the Kozyrev series.

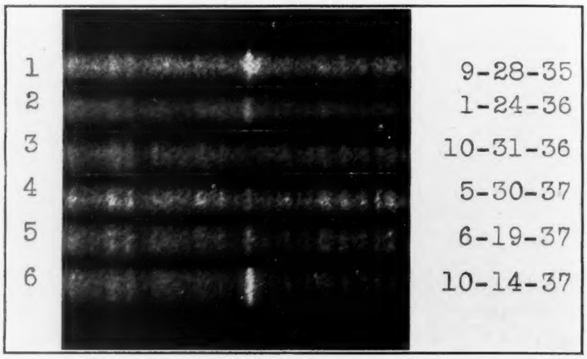
There is previous observational evidence that leakage of gas may occur from the lunar surface inside the crater Alphonsus. In the April, 1957, issue of the *Publications* of the Astronomical Society of the Pacific, Dinsmore Alter published a remarkable series of photographs of Alphonsus, taken on October 26, 1956, with the Mount Wilson 60-inch reflector, alternately in blue and infrared light. The well-known rill at the foot of the west inner slope of Alphonsus is distinct in the infrared pictures but practically effaced in the blue ones. In the adjoining crater Arzachel, however, there is no such striking difference in the visibility of detail. Dr. Alter inferred from this that a temporary obscuration had probably occurred in the western part of Alphonsus, masking the surface from observation at short wave lengths.

J. A.

World-wide Observations of VV Cephei

LAURENCE W. FREDRICK, *Sproul Observatory, Swarthmore College,*
and *Flower and Cook Observatory, University of Pennsylvania*

ASK any astronomer to name the 20 most important stars in the sky, and his list will probably include an object faintly visible to the naked eye in the Milky Way where it crosses the constellation Cepheus. This star, VV Cephei, first attracted attention by its peculiar spectrum, which is that of a cool *M*-type star, with the addition of bright lines characteristic of a hot *B* star. In 1936, the Michigan astronomer D. B. McLaughlin found to his surprise that the bright lines had vanished. Thereupon he suggested that VV Cephei was a binary system, consisting of an *M* star and a *B* star, and that the latter had just gone into eclipse behind the other.

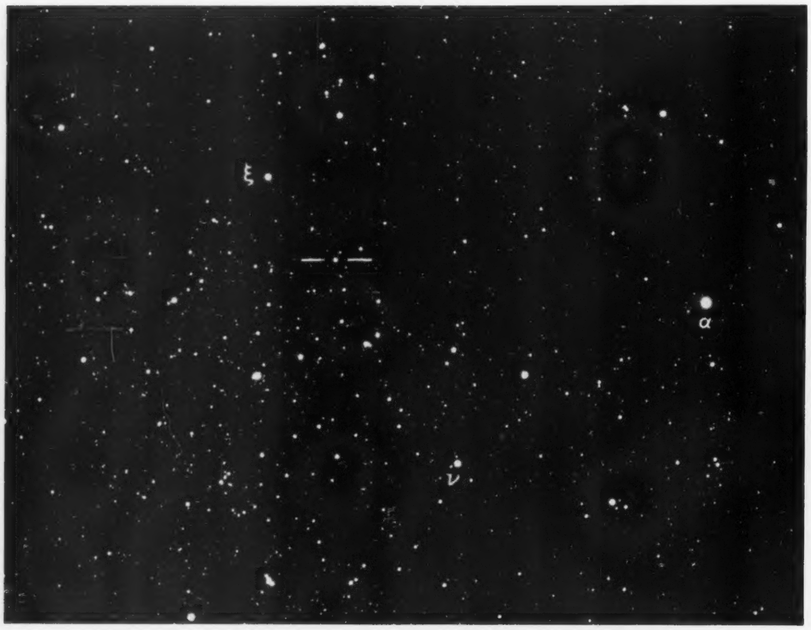


These six spectrograms from the University of Michigan Observatory illustrate the discovery of the binary character of VV Cephei. The bright emission line of hydrogen-beta is centered in each spectrum. It disappeared and reappeared as the blue star from which it originates went into and came out of eclipse behind the large red star.

This interpretation was promptly confirmed by Sergei Gaposchkin's examination of patrol photographs at Harvard Observatory. VV Cephei was indeed fainter than normal by over half a magnitude. Further study has shown this to be one of the most remarkable eclipsing variables known. Every 20.4 years the brightness drops sharply, remains near minimum for 15 months, and then rises again, as the small *B* star passes behind the much larger *M* star. Because the eye is less sensitive to blue light than are ordinary photographic plates, the eclipses are much shallower visually, only about 0.2 magnitude deep.

The spectroscopic observations of VV Cephei during its 1936-37 eclipse showed a striking effect. The spectral lines of the *B* star did not fully regain their normal appearance until the end of 1938 — a year and a half after the eclipse had ended! During this interval, evidently, we were viewing the small *B* star through the very extended and tenuous atmosphere of the *M* component.

It is no wonder that the succeeding eclipse of VV Cephei, due in 1956-58, was eagerly awaited by astronomers. At the suggestion of Commission 42 of the International Astronomical Union, cooperation was arranged among observers. We hoped to get nearly continuous spectroscopic and photometric records of the star's behavior, so that a variation observed by one technique could be correlated with evidence from the other. F. Bradshaw Wood, director of the Flower and Cook Observatory, acted as co-ordinator for this program, and distributed information.



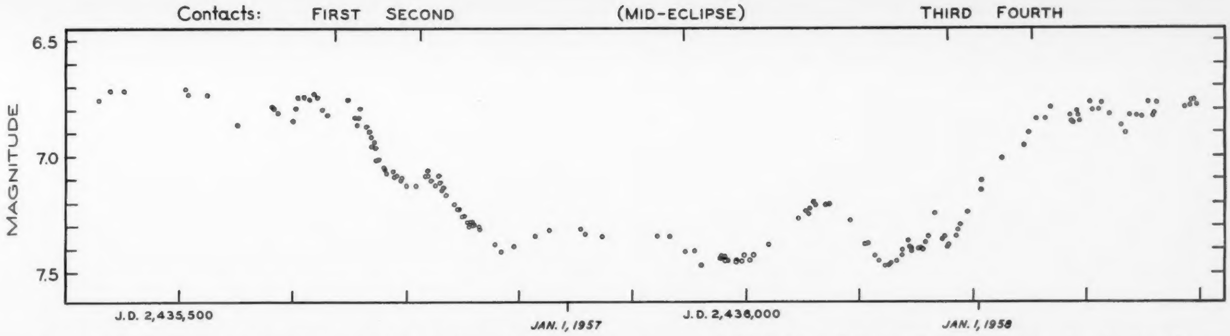
This is the field of VV Cephei on an enlargement of part of a Harvard Observatory patrol plate. Alpha, Nu, and Xi Cephei are indicated, and VV itself is between the short white lines. Though of naked-eye brightness, it appears faint on photographs because of its redness. This 79-minute exposure was taken September 24-25, 1948, with a camera of 1½-inch aperture and 13 inches focal length. Harvard Observatory photograph.

Even a brief listing of the work already reported shows how intensively VV Cephei was observed. The spectrum was regularly photographed by K. O. Wright and A. McKellar with the 72-inch Dominion Astrophysical Observatory reflector, and by McLaughlin with the Michigan 37-inch reflector. In addition, Anne Marie Fringant has secured useful observations at Haute Provence Observatory in France, while at Palomar Observatory Armin J. Deutsch has taken spectrum plates with the 200-inch telescope at selected times.

The Victoria spectrograms cover the entire eclipse. The Michigan series has been maintained since 1932, and Benjamin Peery is now deriving the spectroscopic orbit from this material. His large undertaking is now nearing completion, and will certainly supply an important chapter in the story of VV Cephei.

Numerous photoelectric measurements of brightness have been reported by G. Larsson-Leander (Saltsjöbaden, Sweden), K. Gyldenkerne (Brorfelde, Denmark), T. Herczeg (Budapest, Hungary), and by myself. Larsson-Leander's results are shown here. They have special value because at the high latitude of his observatory the star is circumpolar and never gets closer than 30 degrees to the horizon. Thus he can observe VV Cephei all year.

The plot of my photoelectric observations at Flower and Cook Observatory covers the time when the *B* star was



This light curve of VV Cephei is a plot of photoelectric measurements made in blue light by G. Larsson-Leander during the minimum of 1956-58. Between second and third contacts, the blue star is wholly hidden behind the red component. The curve during that stage is not flat, as might be expected, but shows waves due to the intrinsic light variations of the red component. All diagrams with this article have been prepared by the author.

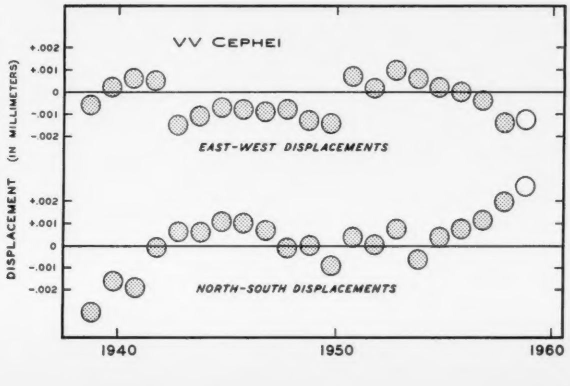
emerging from behind the larger, red component. These measurements, made in yellow, green, blue, and ultraviolet light, show how the depth of the eclipse increases with shorter wave lengths. Herczeg's complete data are not yet available, but will be a valuable contribution, as he has secured observations in the ultraviolet near 3200 angstroms. It is hoped that all these photometric series will continue for some time after the end of the eclipse, which took place about a year ago.

Like all giant and supergiant *M*-type stars, the red component of VV Cephei has small irregular changes in intrinsic brightness — a fact known for many years. This is the cause of the fairly smooth fluctuations inside the eclipse. The two rather abrupt pulses of light around Julian day 2,436,141 and 2,436,166 (October 29 and November 23, 1957, respectively) occurred so close to the expected time of egress that they created two false-alarm announcements of third contact. However, spectra taken at these times showed no real abnormality and no hint of light from the *B* star. Unlike the smooth variation of the *M* star, which has a larger range in yellow light than in other colors, these two pulses were very large in ultraviolet and almost unnoticeable in yellow light. Before and after the eclipse, there is a small, rather erratic brightness variation, due to intrinsic variability of the *B* star superposed on the *M* component's variations.

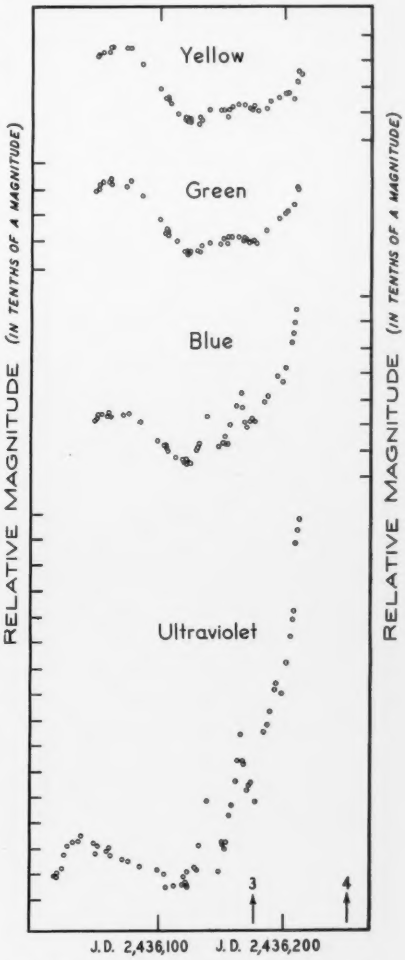
Another important kind of observation of VV Cephei is astrometric. Accurate year-after-year measurements of the position of either component in this binary system should reveal a slight waviness in its proper motion across the sky, as each star is also moving around the center of gravity of the system. The only sufficiently precise technique for these measurements is photographic observation with long-focus refracting telescopes. Such photographs of VV Cephei have been taken for 20 years with the 24-inch refractor of Sproul Observatory. About 1,200 plates have been secured, at an effective wave length of about 5600 angstroms, so only the position of the red star is recorded. I have almost completed the analysis of this material.

Some provisional results of an approximate nature can be cited from the cooperative VV Cephei campaign. The astrometric observations show that the orbit is presented to us very nearly edge on, the inclination to the plane of the sky being almost 90 degrees. The parallax is now found to be about 0.007 second of arc, so that VV Cephei is some 470 light-years distant — only one-tenth of the distance usually cited. The photometric data indicate that the *M* star has only roughly 10 times the diameter of the *B* component, instead of about 100. The depth of the eclipse in yellow light is approximately twice that found in 1936-37.

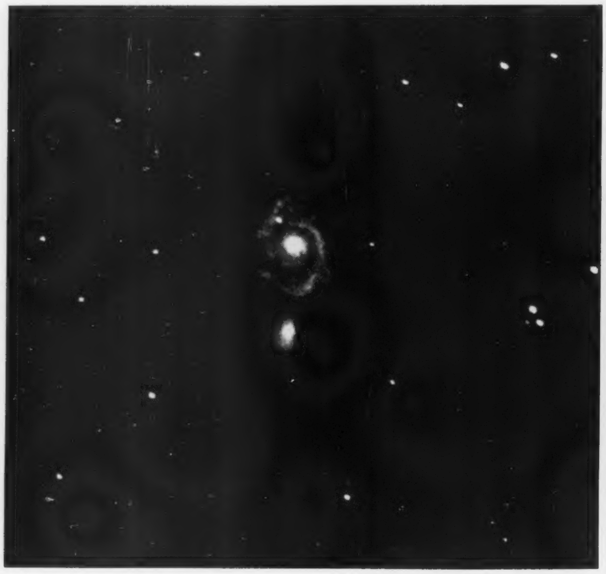
These provisional results suggest that our present ideas about the system of VV Cephei will undergo drastic revision. One possibility is that the red component is not a glorious supergiant, but must be deflated to a reasonable giant-star size. If this is not so, there are contradictions that will require observations over two more periods of the system — 41 years — to resolve. Whatever the case, there is still much to be learned concerning VV Cephei.



The orbital motion of the red component of VV Cephei is shown by the author's measurements of 1,200 Sproul Observatory photographs, on which one millimeter is 19 seconds of arc. The probable errors of the measurements are indicated by the radii of the circles, of which the last ones (unshaded) are provisional.



A plot of the photoelectric observations of VV Cephei by the author, made as the blue star was emerging from behind the red one. Note the two transitory flare-ups of the red star, conspicuous in the ultraviolet and blue curves. Contacts 3 and 4 are marked.



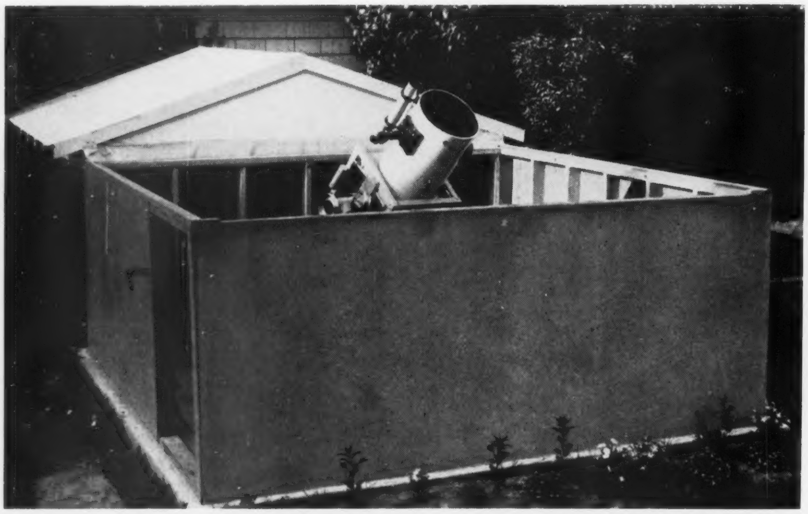
With his 12-inch telescope, the author of this article took these pictures of (left) the Whirlpool galaxy, M51, in Canes Venatici, and (right) the Dumbbell planetary nebula, M27, in Vulpecula. The exposure times were 14 and 12 minutes, respectively, on Eastman Kodak 103a-F emulsion.

Some Suggestions on Astrophotography

GEORGE T. KEENE, *Rochester Academy of Science*

NEARLY ALL of the celestial objects of interest to the amateur observer can be photographed with equipment often available. I have been successful in obtaining good pictures with my 12-inch f/4.3 reflector, which is shown on the front cover of this issue. This instrument is particularly suited for recording nebulae, clusters, and galaxies, as the accompanying photographs of some well-known objects indicate.

The basic principles of astrophotography used in these observations apply to other celestial subjects, even though they range in angular size from aurorae to planetary disks, and in brightness from the sun to faint galaxies. In planning photographic work, we must consider the size of the instrument's field, the scale of the photograph, the speed of the optical system, and the emulsion sensitivity. These factors are interrelated, and if existing equipment is to be used, one of them may have to be given less consideration than the others.



The author's back-yard observatory is 10 feet square and four feet high; the roof rolls off to the north to give an almost unobstructed southern horizon.

Field size. The angular extent of the object to be photographed indicates the size of field that should be used. For example, pictures of the moon, sun, planetary disks, and many galaxies can be obtained with a field of $\frac{3}{4}$ degree or less. For extended galaxies, nebulae, and star clusters, a two-degree field or larger is desirable. Milky Way areas and bright comets may need 15 degrees for full coverage, and fields up to 60 degrees wide are in order for meteors, artificial satellites, and aurorae.

In reflecting telescopes with parabolic mirrors, the field is severely limited by coma, particularly for mirrors faster than f/5. The 6-inch f/8 reflector in common use by many amateurs has a usable field of only one or two degrees. For different-sized telescopes of the same focal ratio, the *linear* diameter of the useful field is nearly constant; it is less than one inch for my 12-inch f/4.3 reflector, and $\frac{1}{2}$ to $\frac{3}{4}$ inch for the 200-inch f/3.3 Hale telescope.

Lens systems providing fields of 10 or 15 degrees with good definition are generally available. For larger fields with excellent image quality, Schmidt cameras can be used.

Plate scale. The scale of an optical

FILMS AND EXPOSURE TIMES FOR ASTROPHOTOGRAPHY

Equipment	*Object*	*Film and developer*	*Exposure time*
Fixed camera, full aperture, EFL* 2" to 12"	Aurorae, satellites, meteors, star trails	Ektachrome, exposure index 32 or higher; Tri-X; Royal-X Pan	10 sec. to 3 hr.
Guided camera, full aperture, EFL* 2" to 40"	Stars, comets	Tri-X; Royal-X Pan	10 min. to 3 hr.
Guided telescope, EFL* 50" to 100", penta prism or equiv. for sun	Nebulae, galaxies	Tri-X; 103a-F	10 min. to 1 hr.
	Sun, moon	Panatomic-X or Micro-File, 6 min. in D-19	1/500 to 1 sec.
Guided telescope, EFL* 100" to 1,000"	Lunar craters, planets	Panatomic-X, forced to exp. index 200; Ektachrome, forced to exp. index 250	1/10 to 10 sec.
	Sunspots	Micro-File, 6 min. in D-19	1/200 to 1/25 sec.
	Nebulae, galaxies	Tri-X; 103a-F	10 min. to 3 hr.

*Effective focal length.

system is the ratio between the linear and angular dimensions in the focal plane; it depends only on the equivalent focal length of the optical system. A convenient formula is:

$$\text{Scale (inches per degree)} = 0.0175\ \text{EFL},$$

where the effective focal length, EFL, is expressed in inches.

Since the angular diameters of the sun and moon are about half a degree, their images on the plate or film are approximately EFL/115 inches in diameter. For example, the focal image of the moon obtained with a 6-inch f/8 reflector is only about 0.4 inch in diameter.

System speed. Except in solar work, astronomical photography deals with faint light sources, and the speed of the optical system is usually the limiting factor. As longer and longer focal lengths are used to reveal smaller detail, the exposure time must increase unless the aperture is enlarged. In practice the exposure time should be as short as possible. Even for the sun and moon, the shorter the exposure the less the picture will be blurred by atmospheric turbulence, and for very faint objects it is important to minimize the labor of protracted guiding on a star.

Using the fastest possible films to cut exposure times is not always the best answer, as they are usually objectionably grainy. Another factor in the choice of film and developer is the amount the negative is to be enlarged. The accompanying table is a guide to films, exposures, and developers for astrophotography, based on my personal experience.

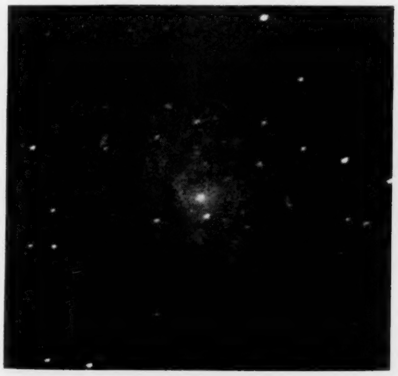
Forced development is a useful technique. For faint stars or nebulae, Kodak Tri-X film can be force-developed to exposure indexes of 1,500 or 2,000 by 18 minutes in a phenidone-type developer. Fine-grain negatives suitable for enlargement up to 10 times can be obtained for the moon and planets on Panatomic-X film developed to a speed of 200.

Color film is useful in planetary photography, as color contrasts often bring out increased detail. Since a film index of at least 200 is needed if exposures are to be kept reasonably short, either Ektachrome or Anscochrome will require special forced development.

Solar photography. This requires separate mention, since the sun's light is so great that it creates special, serious problems. With a 4- or 6-inch telescope, the concentrated glare of the focused solar image is so intense that filters placed at the eye end of the telescope are inadequate and dangerous. For photographing the sun with my 12-inch reflector, I have an unsilvered penta prism inside the focus, so that only 0.16 per cent of the light reaches the eyepiece. Even with the penta prism in place, however, a neutral density filter must be put over the eyepiece for visual and photographic use.

My solar photographs are taken by eyepiece projection, through neutral filters of density 1.0 or 1.5. A 35-mm. camera is held over the eyepiece for the exposures of 1/150 to 1/500 second on Kodak microfilm. If no neutral filter is available, a processed piece of unexposed Kodachrome may be used.

Focal ratio. While simple trial and error is often the best way to determine



At the right is the Great Nebula in Orion, a 20-minute exposure by the author at the prime focus of the 12-inch reflector. At the left is the galaxy Messier 101 in Ursa Major, whose spiral arms are recognizable on this 17-minute exposure, but Rochester sky conditions prevent procuring a better negative of this faint object. Success in photographing nebulae and galaxies depends on exposing only until the film background has a density of 0.6 or 0.7, as further exposure merely loses detail in the plate fog. Faster emulsions shorten this optimum exposure time, but do not give a deeper limiting magnitude for any particular optical system.

The Lagoon nebula in Sagittarius, M8, exposed 10 minutes on 103a-F film. This fine showpiece of the sky is associated with a galactic cluster, NGC 6530, here seen centered in the left-hand portion of the nebulosity.

the correct exposure time, it is helpful to know the equivalent focal ratio (f) of the optical system. For a single lens or mirror, this is $f = F/A$, where F is its focal length and A the aperture.

If the photograph is taken by projection through an eyepiece of focal length F', the formula becomes

$$f = (L \times F)/(A \times F'),$$

where L is the distance from the eyepiece to the film.

A third arrangement often used is to mount a camera with a lens of focal length F'', focused for infinity, behind the telescope eyepiece. In this case,

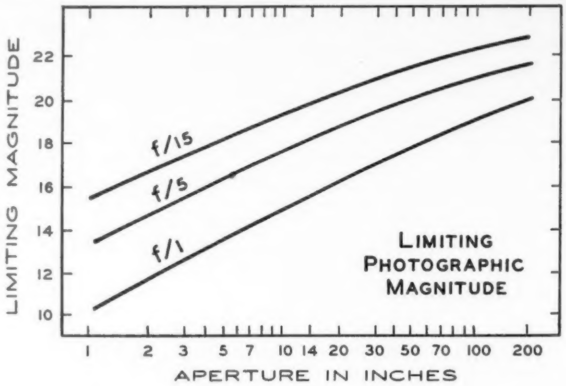
$$f = (F'' \times F)/(A \times F').$$

Once this f/number has been calculated, we can estimate the exposure time required, if the correct exposure on the same object is known for a previous setup. *Exposure time is proportional to the square of f.* For example, if it has been found that the proper exposure time is one second at f/16, it will be four seconds at f/32. While this relationship is a valuable guide, it is not rigorous, because at very faint light levels the film response is less than it should be.

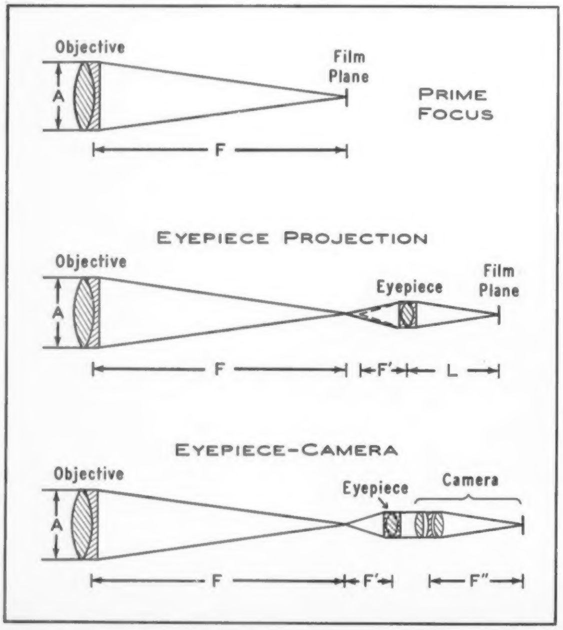
Nebular photography. Here we are concerned with deep-sky objects, such as diffuse nebulae, galactic clusters, globular clusters, and galaxies. For this work my 12-inch is well suited, as it has a focal length long enough to show some detail, yet is fast enough for good prime-focus exposures of 10 to 20 minutes.

Because of the background brightness of the night sky, which fogs the negative, exposures cannot be prolonged indefinitely. A galaxy or nebula is not recognizable on a photograph unless its surface brightness is at least one-sixth that of the night sky, regardless of exposure time. For such extended surfaces, the efficiency of a camera depends on its f/number rather than on its aperture.

In general, the faster the film the shorter will be the time after which further exposure will be useless. Best for nebular photography are the Kodak spectroscopic emulsions, of which I have used the blue-sensitive 103a-O and the panchromatic 103a-F. These coatings are made to order only,* and the amateur may prefer regularly available products. For exposures of up to 20 or 30 minutes, Kodak Tri-X and Royal-X Pan are suitable, but for longer times Plus-X is actually a faster film than Tri-X. The films should be developed for maximum speed, but fine-grain developers should be avoided, as these often cause a loss of detail.



The faintest star a telescope can reach is determined by its aperture and focal ratio. Read from the aperture scale at the bottom to the appropriate curve, then left to the limiting magnitude.



Three ways of carrying out astrophotography are shown here. At the top is the simple arrangement where the film plane coincides with the prime focus of the objective or mirror. In the second case, a good eyepiece (drawn schematically) projects the image, the ocular being placed somewhat farther from the prime focus than its own image plane for parallel light. In the third case, however, where a camera lens is also used, the eyepiece does project parallel light to that lens, here shown in the form of a Cooke triplet.

Stellar photography. Sky fog also sets a limit to the faintest stars attainable by photography with a particular instrument, and extending the exposure time beyond a certain length brings no further gain. The limiting magnitude depends mainly upon the aperture of the telescope, but increasing the f/number helps by diluting the background brightness of the sky.

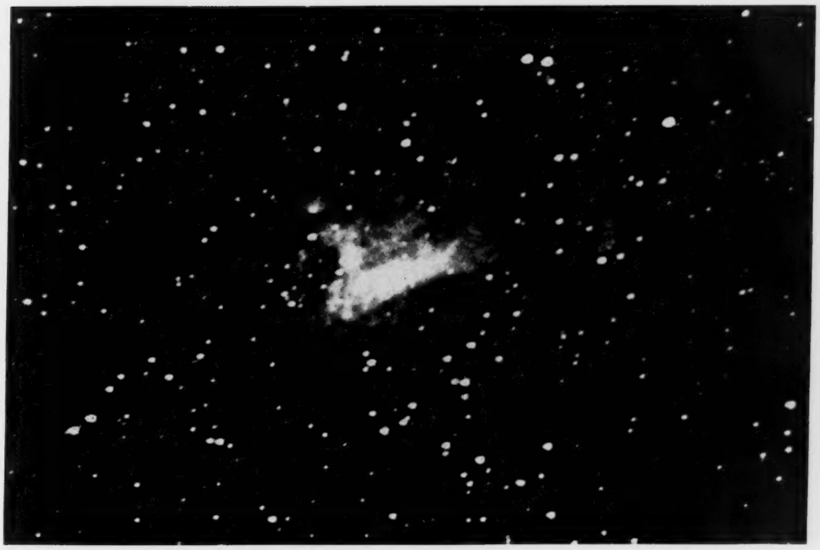
The accompanying graph shows the magnitude of the faintest stars whose images can just be distinguished from the sky fog. The predictions assume good sky

*Write Special Sensitized Products Sales Division, Eastman Kodak Co., Rochester, N. Y.

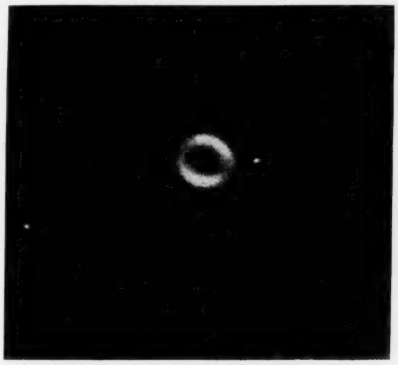
conditions, excellent optics, and error-free guiding. While the limiting magnitude is given as 17 for a 12-inch f/4.3 telescope, the skies near Rochester, New York, prevent me from reaching fainter than magnitude 15.

The amateur photographer of star fields, artificial satellites, meteors, and the aurora should use the fastest emulsions possible. Stars as faint as magnitude 8 or 9 can be recorded on Kodak Royal-X Pan with a 2-inch f/2 lens in only five seconds. It is now possible for an amateur, using the fastest films and lenses, to make his own sky survey with virtually snapshot exposures from a fixed tripod.

Guiding. Astrophotography with long focal lengths or extended exposure times requires a good equatorial mounting properly oriented. A driving motor is necessary for focal lengths of two feet or more, and if the exposures are more than half an hour in length. In any event, the telescope needs a smooth-working slow-motion control in right ascension. The key to success will be good guiding. The guide star need not be one that is being photographed.



The Horseshoe or Omega nebula, M17, in Sagittarius, was photographed at the prime focus of the 12-inch reflector, a 10-minute exposure on 103a-F emulsion. Faint nebulosity has been recorded in the right-hand part of the field. Small guiding errors produced slightly elongated star images.



This 20-minute exposure on the Ring nebula in Lyra, made by eyepiece projection, shows the faint star inside.

My 6-inch f/8 guide telescope is rigidly mounted parallel to the optical axis of the 12-inch reflector. The guiding eyepiece is 250x, but 500x or more would be even better. The guide star must be kept on the intersection of the cross wires at all times throughout the exposure. If it moves away, it must be brought back promptly with the aid of the slow motions. Probably 30 per cent of my negatives are unusable due to some form of guiding error, although I am constantly striving to reduce this percentage.

The demanding requirements of guiding are illustrated by the accompanying Ring nebula picture. It was a 20-minute exposure, the image being projected through a 1-inch eyepiece to increase the plate scale. The resolution of this negative was no better than three or four seconds of arc, but it indicates that the 16-foot equivalent focal length was kept pointing continually within a circle of one inch at a distance of a mile.

LETTERS

On page 87 of the December issue, Mrs. Hedi E. Lattey complained in verse of the hardships of being an amateur astronomer's wife. Her poem told feelingly of the plight of the telescope widow. This housewife from Vernon, British Columbia, has been promptly challenged by two other wives, who have composed these poetic rebuttals:

To an Amateur Astronomer's Wife

Come on now, old dear, let's cheer up and smile!
You've married a man who is well worth the while.
His eyes may be glued to a beautiful star —
But it's nicer than sitting blear-eyed at a bar.

In front yard, or back yard, on mountain or knoll,
An astronomer's quite an inquiring soul.
He's happy at his telescope whenever he sees
The dazzling diamonds of bright Pleiades,

Or a galaxy millions of light-years away,
Or a star that exploded one prehistoric day,
Or Jupiter's moons, or Saturn's broad rings —
To astronomers these are all challenging things.

No wife will be lonely, unhappy, forlorn,
If she'll join with her spouse in the wee hours of morn
In this science that calls to the greatest of men,
And how proud she will be — out there freezing with him!

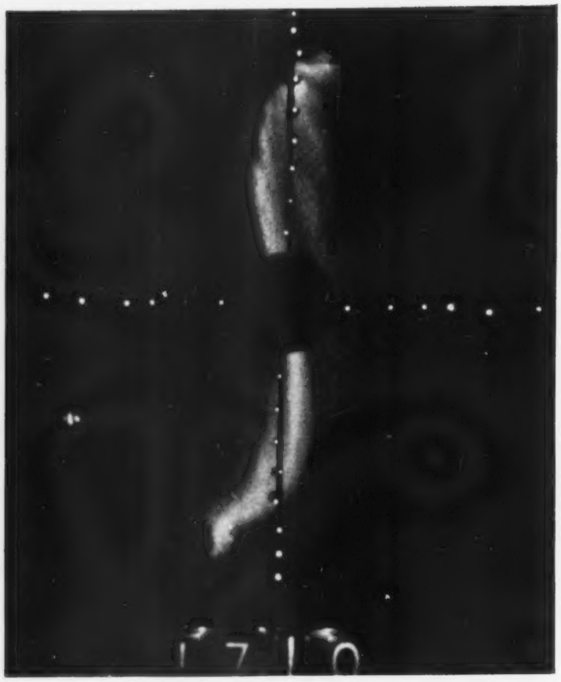
Mrs. Mary H. Ganser
Bloomfield, N. J.

One Astronomer's Wife

I awake a few hours preceding the dawn
And find my astronomer-husband is gone.
I bound out of bed — I cannot have this!
He's doubtless found something that I must not miss.
The moon, stars, and planets, the great nebulae,
Are worlds that my husband has opened for me.
Orion and Saturn are friends of us both,
Our telescope brings us a new means for growth.
What a wonderful thing has come into our life!

My husband, I note, is increasingly mine,
As together we go where the galaxies shine.
When he's perched upon Plato's precipitous rim
He is not there alone — I accompany him.
At predawn and midnight, in front of our house,
I gaze into far distant space with my spouse;
And while at breakfast we both may be tired,
I'm elated in sharing new knowledge acquired.
Behold lucky me, an astronomer's wife!

Mrs. Lorena M. Cole
Farmington, Mich.



This rayed auroral arc, photographed at Wilkes Station on June 25, 1957, is typical of many observed there, extending north to south.

Aurora Observations in Antarctica

WILKES STATION auroral observatory is one of six established on the Antarctic continent as part of the United States International Geophysical Year research program. It is located on the coast of Antarctica nearest western Australia, at 66° 15′.5 south latitude, 110° 31′.2 east longitude. It is on the same meridian as the geomagnetic south pole and only 12 degrees north of that point.

Ralph Glasgal, of New York City, spent many months at Wilkes Station carrying out auroral observations on a technical program set up by Norman J. Oliver, Air Force Cambridge Research Center. Mr. Glasgal has sent the accompanying direct photographs of the aurora australis, and makes the following comments:

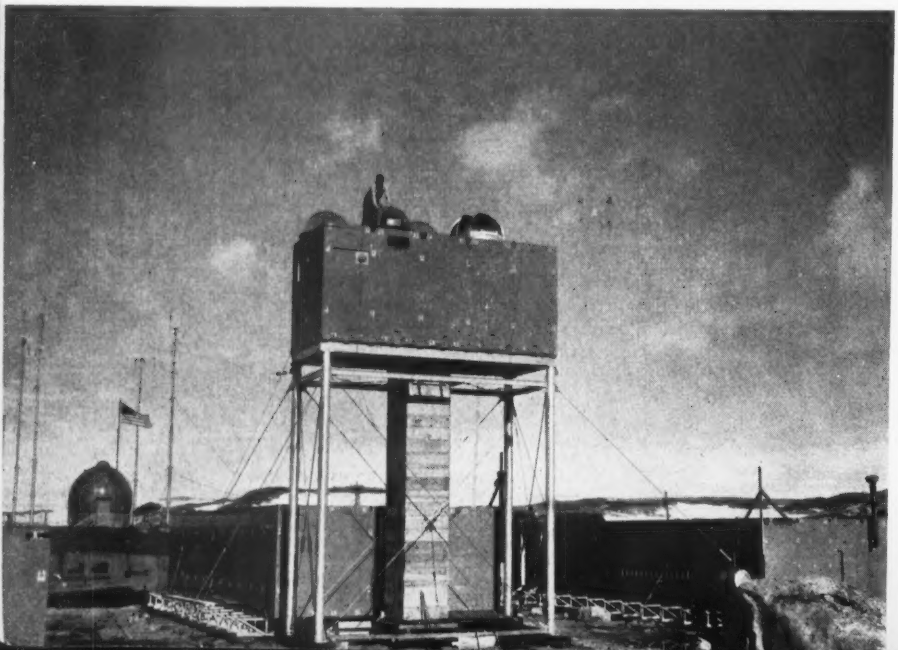
"Despite its distance from the maximum zone of southern aurora (see SKY AND TELESCOPE, April, 1958, page 268), Wilkes Station has an aurora at some time during every clear night. Much of the aurora appears in the low north region of the sky, in the direction of the maximum zone, but it is a rare night when there is not also a more local display. The long nights of May, June, July, and August are best, brighter displays with short-lived colored forms often occurring.

"During 1957, most of the aurorae consisted of rayed arcs or bands. Draperies, coronas, rays, or ray bundles were common features of stronger displays. Not a single classical homogeneous arc was observed, although this type is generally common in regions near the auroral zone.

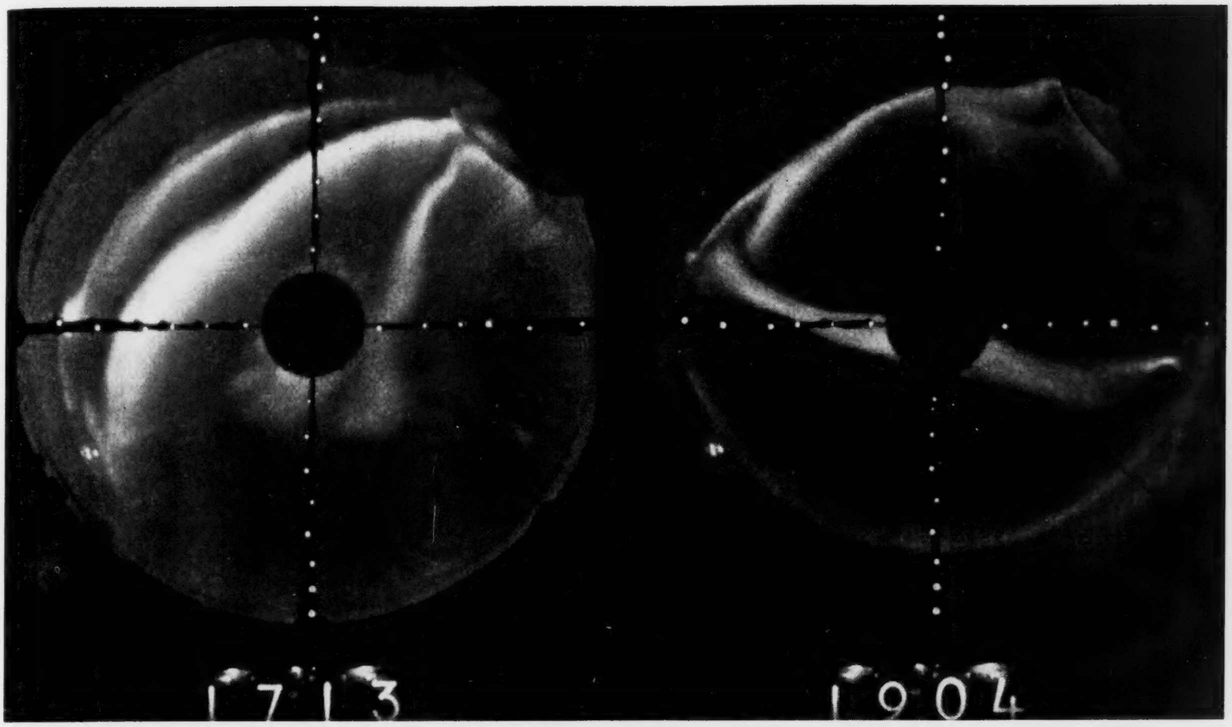
"By far the most unusual characteristic of Wilkes Station aurorae in 1957 was the complete randomness in the direction of alignment of the arcs. The pictures show arcs running in radically different directions. It was not unusual for the orientation to change between displays several times in the course of a single night, though in general each display retained a fixed direction throughout its duration.

"The classical studies of the orientation of rayed arcs for stations in the north polar regions by Störmer, Fritz, Vegard, Krogness, and Harang have all shown that the direction of arcs was approximately perpendicular to the geomagnetic meridian. That is, arcs generally stretch from east to west parallel to a circle of geomagnetic latitude, seldom deviating by more than 15 degrees from the observed mean orientation. At some points within the auroral zone, however, the difference may be as much as 30 degrees, the greatest deviations from the expected theoretical orientation occurring where the compass points at right angles to the direction of the magnetic pole.

"Wilkes Station lies in such a position in the Southern Hemisphere – the pole lies due south and the compass needle points almost due east. But variations of auroral arc orientation up to 90 degrees about any reference value occur with such regularity that even the existence of a mean value of orientation is problematical and will require a statistical analysis of the observations to establish. Although reports from the other Antarctic stations are incomplete, they seem to indicate that while large average deviations from the theoretical mean exist, the randomness is not nearly as pronounced. At Thule, Greenland, the average arc



Some of the plastic domes and instrument shelters for the auroral camera and other equipment are seen at the top of this tall structure at Wilkes Station. The central column encloses the observer's access ladder. All photographs courtesy Air Force Cambridge Research Center.



Two auroral photographs taken at Wilkes Station with the all-sky camera. The one at the left was on June 30, 1957, at 17:13, the other a day later, at 19:04. The dark central shadow is from the secondary mirror, and along the diagonal supporting arms are lights indicating 10-degree intervals of altitude. North is at the bottom.

runs almost parallel to the geomagnetic meridian, but the deviation from this average by any individual arc is very small.

"The existence of large numbers of arcs extending from north to south opens up a new field for auroral motion studies. In the past, east-to-west motions of individual rays or bright spots have been made confusing by the movement of the arc as a whole from north to south. But when an arc is turned 90 degrees and lies near the observer's meridian, its movement as a unit in the east-to-west direction becomes easily apparent.

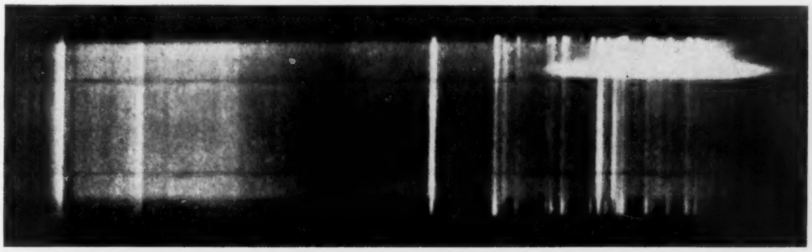
"At Wilkes Station all auroral arcs with any appreciable extent north to south appeared to drift steadily to the west regardless of the time of night. This strongly suggests that the earth may be rotating under a fixed display pattern. On one occasion a very strong north-south arc was seen to rise in the east, drift slowly across the sky, and finally set in the west still more-or-less unchanged by its transit across the heavens. Most arcs are too short-lived to make the complete transit, but they have a similar motion. Within such an arc, however, rays and bright spots course rapidly back and forth in the north and south directions."

In addition to the auroral work with all-sky cameras, studies of the twilight, night sky, and aurora were made at all of the United States' IGY Antarctic stations. At the South Pole, observations with a patrol spectrograph were made by Arlo U. Landolt, a graduate student in astronomy at Indiana University, who has sent the accompanying spectrogram, writing:

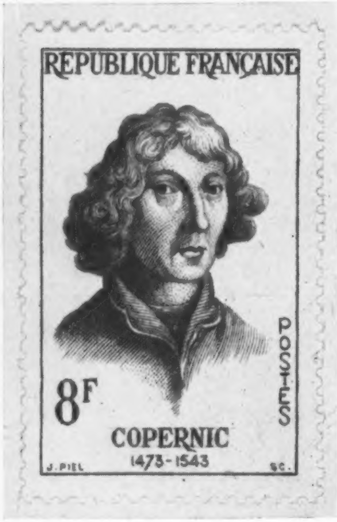
"A patrol spectrograph is set up to obtain several spectra automatically during a selected observing interval. The principal designers were Aden B. Meinel and Mr. Oliver, and the instruments were built by the Perkin-Elmer Corp. Light from a band in the sky about two degrees wide and 165 degrees long, or roughly a strip from horizon to horizon, is admitted through a slit oriented parallel to the geomagnetic meridian. Beneath the slit, a fish-eye lens brings the light to bear on a Petzval lens system, which collimates the rays for passage through a transmission grating. Then a very fast (f/0.625) semi-solid Schmidt camera images the dispersed light on 16-mm. Kodak 103a-F spectroscopic film.

"The spectrogram was taken on May 9-10, 1957, at 13:17 UT, at the South Pole station. The bright auroral line in the center is the 5577-angstrom line of neutral oxygen. This line, in the green section of the spectrum, was monitored by a photometer system utilizing a 1P21 photomultiplier tube. While an exposure was being made, the monitor provided a cumulative count of light photons, and when the proper total was reached to insure a good spectrum, the exposure was stopped and another started automatically.

"The pair of bright lines to the right side of the green line, at wave lengths of 6300 and 6364 angstroms, are also due to neutral oxygen. The bands toward the violet are caused by ionized molecular nitrogen. Most of the remaining bright lines are of neutral oxygen or nitrogen, while the bands are predominantly those of neutral or ionized nitrogen molecules."



A spectrum of the aurora taken by Arlo U. Landolt at the South Pole on May 9-10, 1957, at 13:17. Violet is toward the left, red to the right. From the right end of the picture, in inches, are these bright lines and bands: $1\frac{1}{8}$, 6364; $1\frac{1}{4}$, 6300; $2\frac{1}{4}$, 5577; 4, 4278, $4\frac{1}{2}$, 3914. The last two of these are emitted by ionized molecules of nitrogen in our atmosphere.



Some Astronomical Stamps—I

Alphonse P. Mayernik

Left: Nicholas Copernicus, Polish astronomer, 1473-1543; 8 francs, dark brown. Right: Sir Isaac Newton, English philosopher and mathematician, 1642-1727; 18 francs, deep blue. Both stamps were issued by France in 1957.

More than a dozen countries are represented in my collection of modern astronomical stamps, which has taken some years of searching and shopping to compile. Having both astronomy and stamp-collecting as hobbies, I noticed the many astronomers honored on postage stamps, as well as certain constellations, such as the Southern Cross, which appeared frequently. To date, this collection has more than four dozen astronomical stamps in it, and is still growing.

The stamps to be illustrated in this series include astronomers and others who worked in the field, constellations, observatories, solar eclipses, and various celestial subjects. This first installment covers the earlier scientists; those of a more contemporary period will be on stamps shown in the next part.

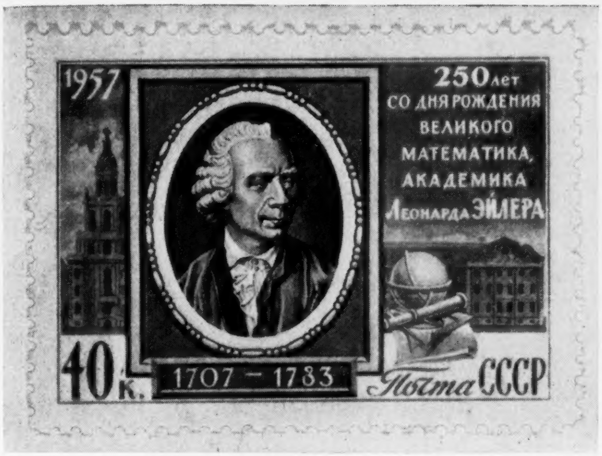
The two French stamps at the top of this page are from a set of seven issued in 1957 honoring illustrious foreign scientists, authors, and artists. Copernicus was the Polish author of *De Revolutionibus,* who insisted that the sun, not the earth, is in the center of our planetary system. Newton, the English philosopher and mathematician, besides his brilliant explanation of celestial motions in terms of gravitation, invented the Newtonian reflecting telescope and made other valuable contributions to optics.

Above left: Tycho Brahe, Danish astronomer, 1546-1601; 20 ore, dark red.

Above right: Ole Römer, another Danish astronomer, 1644-1710; 20 ore, henna-brown. Denmark released these stamps, that of Brahe in 1946, that of Römer in 1944, on the anniversaries of their births.

Galileo Galilei, Italian scientist, 1564-1642, was the subject of a series of four Italian stamps in 1942. His portrait is on the 50-centesimi one at the left, with a brown-violet frame and violet inset. The 10-centesimi issue, dark orange with red-lake inset, shows Galileo teaching at Padua, 1592-1610.

On the two Danish stamps above, Tycho Brahe was the astronomer who was granted the little island of Hveen by King Frederick II of Denmark, where he built a magnificent observatory, Uraniborg, and where he and his assistants completed a 21-year series of naked-eye observations more exact than any made up to that time. He moved afterward to Bohemia, where in a castle near Prague he was joined by the young Johannes Kepler, who later discovered the laws of planetary motion. Ole Römer was the young Dane who, in Paris, discovered and



Leonhard Euler, Swiss mathematician, 1707-1783. Issued by Russia in 1957; 40 kopecks; lilac background, gray inset.

Another stamp honoring Copernicus. This 20-groszy brown issue is one of a pair put out by Poland in 1953 on the 480th anniversary of Copernicus' birth. The other (not shown) is in deep blue, and pictures him with a chart of the sun and planets. A 1955 Russian stamp is similar to the one illustrated here.

measured the velocity of light, and who later made the first transit instrument.

The four Italian stamps portraying events in the life of Galileo include one (25 centesimi) showing him with the doge of Venice. This followed Galileo's demonstration of his revolutionary instrument

Johannes Kepler, German astronomer, 1571-1630. Dark gray-blue, this stamp was issued by Austria in 1953, face value 1 schilling 25 groschen.

to the officials of Venice, of whom he wrote: "Many noblemen and senators, although of great age, mounted the steps of the highest church towers at Venice, in order to see sails and shipping that were so far off that it was two hours before they were seen steering full sail into the harbor without my spy-glass, for the effect of my instrument is such that it makes an object 50 miles off appear as large and near as if it were only five."

Leonhard Euler, the greatest mathematician of his day, did important work, much of it in Russia, on the motions of the planets, moon, and comets.

Although only four stamps of Copernicus are mentioned here, he was also on two 1923 Polish stamps, a 1,000-marka denomination printed in indigo blue, and a 5,000-marka one in rose.

Some recent astronomical issues may be missing from this collection, although I have searched through Scott's *Standard Postage Stamp Catalogue,* 1958, at least a dozen times. If any readers know of other stamps of this kind, I would appreciate it if they would drop me a line at 6708 53rd Rd., Maspeth 78, N. Y.

(To be continued)

Right: Roger Boscovich, S. J., 1711-1787, a Slovene who was well known as a talented mathematician, astronomer, inventor, philosopher, engineer, poet, and diplomat. Issued by Croatia in 1943 (at that time independent of Yugoslavia), this 12.50-kuna stamp is dark violet-brown; a 3.50-kuna one has the same design in copper red.

Galileo presents his telescope to the doge of Venice, 1609, in the 25-centesimi stamp, left, of the 1942 Italian series. This has a gray-green frame with a green center. Right, the 1.25-lire issue is Prussian blue, with a blue inset showing the elderly Galileo seated among friends at Arcetri, 1633-1642.

Amateur Astronomers

NATIONWIDE AMATEUR ASTRONOMERS CONVENTION

DENVER, COLORADO, will become the amateur astronomy center of the United States this August 28-31, when hundreds of enthusiasts will gather here for the first truly national meeting of amateur astronomers. Every amateur is welcome, whether or not he is a member of a society.

For the first time, the Western Amateur Astronomers and the Astronomical League will meet jointly. The American Association of Variable Star Observers and the Association of Lunar and Planetary Observers will also participate. Time will be set aside during the conference for each of these four organizations to hold its own business sessions.

Five societies in the Mountain States region are arranging the convention. The host is the Denver Astronomical Society, assisted by the clubs from Boulder, Colorado Springs, and Pueblo, Colorado, and from Cheyenne, Wyoming.

The headquarters will be at the University of Denver, which has housing accommodations for about 850 persons. The university's facilities will become available at noon on Thursday, August 27th, and the rest of the day is to be given to setting up exhibits, informal get-togethers, and registration.

Registration is now open to early planners. Until May 1st, the registration fee is $2.00 each person and $3.00 for a family; after May 1st, $2.50 per person and $3.50 per family. Remittances should be mailed to Ned Onstott, 2421 Second Ave., Pueblo, Colo.

Two new dormitories will be available, and reservations may be made with Mr. Onstott as well. A total of 430 single beds in two-bed rooms cost $3.00 a day per person. For small families there are 64 one-bedroom apartments, with an average of three beds per unit, at $7.00 each day. For larger families and groups, two-bedroom apartments accommodating five or six persons cost $10.00 per day.

Amateurs desiring program time should send short abstracts of their talks by February 1st, to the appropriate person named below. None will be read in absentia; reading time is not to exceed 20 minutes. All papers selected will be printed in the *Proceedings*, which will be on sale at the registration desk.

If you are an unaffiliated amateur and do not belong to any of the organized groups listed below, submit your abstract to W. H. Dexter, 755 Salem St., Denver 8, Colo.

If your club is a member of the Astronomical League, contact Mrs. Jane Gann, 420 N. Cassaday Rd., Columbus 9, Ohio; juniors in the AL, Kay Gross, 3001 6th Ave., Ft. Worth, Tex.

Western Amateur Astronomers should write any of the following: George Perkins, 4636 Vineta Ave., La Canada, Calif.; John P. Treleven, Box 102, Fairfax, Calif.; Arthur S. Leonard, 740 Elmwood Dr., Davis, Calif.

Walter H. Haas, 1835 Evans Pl., Las Cruces, N. M., will consider papers from ALPO members; Mrs. Margaret Mayall, 4 Brattle St., Cambridge 38, Mass., those for the AAVSO.

The tentative plans include several trips to astronomical institutions in Colorado. For instance, after the convention opening on Friday, there will be an afternoon field trip to the National Bureau of Standards and the radio telescope installations on Gun Barrel Hill in Boulder. That evening the first of two banquets will be held, with a well-known professional astronomer as speaker.

Following the Saturday morning sessions, we are scheduling a bus caravan to Colorado Springs to visit the new Air Force Academy and planetarium, as well as a chuck-wagon dinner and show in the internationally famous Garden of the Gods.

Sunday's program will be devoted to papers and separate business meetings by the participating associations. A public exhibit of amateur instruments will commence at 6 p.m., followed by a star party.

On Monday evening there will be an all-amateur award banquet, with Thomas A. Cragg of Mount Wilson and Palomar Observatories as guest speaker. The AL and WAA will also present their annual awards.

Although the formal meeting will close August 31st, there will be an additional field trip to the High Altitude Observatory in Climax, Colorado, on September 1st, also by chartered bus.

During the meeting we are arranging for a baby-sitting service at a nominal price. Nonastronomical wives may take shopping tours and view a fashion show. The convention is a part of the year-long celebration commemorating Denver's centennial, the theme of which is Colorado's "Rush to the Rockies."

We will announce more details as soon as further arrangements are made.

KEN STEINMETZ
1680 W. Hoye Pl.
Denver 23, Colo.

JUNIORS IN FLORIDA AND MISSOURI

A dozen juniors have formed the Astronomy Club of Rockledge, Florida. The president is Perry D. Butler, P. O. Box 229, Rockledge, Fla.

Last May, a group of teen-agers organized the Junior Astronomers League of Joplin, Missouri. Meetings are on the second and fourth Friday of each month. Interested persons may contact David Owen, 1720 Murphy Blvd., Joplin, Mo., for further information.

BIRMINGHAM, ALABAMA

The Shades Valley Astronomy Club is currently seeking a suitable site to mount its recently acquired 12-inch reflector. The society meets monthly on the third Tuesday, at 7:30 p.m. in the Homewood Public Library.

This year's officers are: N. H. McCoy, president; A. R. Houston, vice-president; and W. H. Higgins, treasurer. The new secretary is G. C. Morgan, 1608 Barry Ave., Homewood, Ala.

CLEARFIELD, PENNSYLVANIA

The newly organized Amateur Astronomers of Clearfield have 10 members. The person to contact is Leonard Gearhart, Jr., 114 S. 5th St., Clearfield, Pa.

THIS MONTH'S MEETINGS

Austin, Tex.: Forty Acres Astronomy Club, 8 p.m., physics building, University of Texas. January 13, Stiles M. Roberts, University of Texas, "Binary Stars."

Baltimore, Md.: Baltimore Astronomical Society, 8 p.m., Enoch Pratt Library. January 19, Dr. Ruth Hedeman, McMath-Hulbert Observatory, "Solar Flares During the IGY."

Cambridge, Mass.: Amateur Telescope Makers of Boston and Bond Astronomical Club, 8 p.m., Harvard Observatory. January 8, Dr. Walter Baade, Harvard Observatory, "The Telescopes at Mount Wilson and Palomar Observatories and Their Operation."

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. January 9, Dr. John B. Rogerson, Jr., Princeton University Observatory, "Solar Photography from 80,000 Feet."

Dallas, Tex.: Texas Astronomical Society, 8 p.m., Health Museum Planetarium. January 26, Charles S. Frazier, "Some Problems of Cosmological Theories."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. January 7, Dr. Sarah Lee Lippincott, Sproul Observatory, "Profiles of a Few Stellar Neighbors."

New York, N. Y.: Junior Astronomy Club, 8 p.m., Waverly building, New York University. January 16, Dr. Milton K. Munitz, New York University, "The Development of Cosmology."

Philadelphia, Pa.: Rittenhouse Astronomical Society, 8 p.m., Franklin Institute. January 16, Dr. E. J. Opik, Armagh Observatory, "The Surface Conditions on Our Nearest Neighbors."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. January 3, James C. Fidler, U. S. Weather Bureau, "Planetary Weather Theories."

An Observatory-Planetarium in Idaho

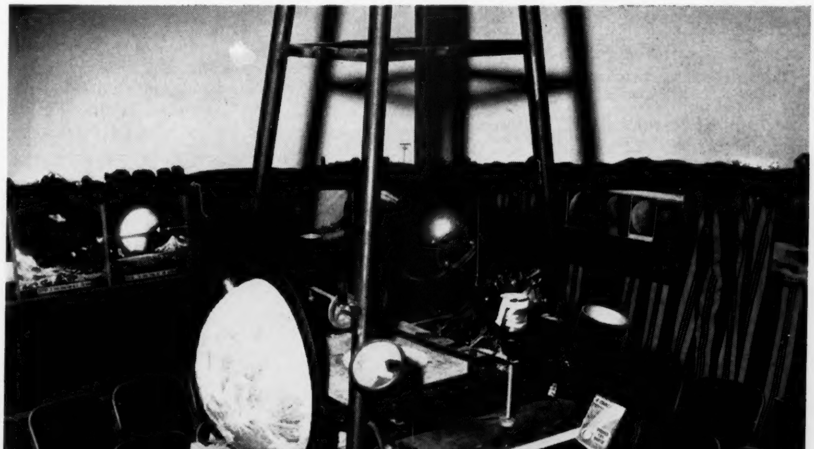
A COMBINATION observatory and planetarium has been built and presented to his community of 18,000 persons by Norman Herrett of Twin Falls, Idaho. He received assistance in the form of equipment, materials, and labor, from about 37 local business firms and individual members of the Southern Idaho Amateur Astronomers.

Norman Herrett stands in front of his combination planetarium and observatory, alongside one of the many telescopes he has built. The building is entirely of fiberglass and steel, and a 12-inch reflector is on the second floor. Its pier is a pipe-frame structure that extends upward through the planetarium chamber on the first floor, as seen in the picture below. The pipe pyramid also serves as a support for the planetarium projector, plastic models of the moon, cases containing meteorites, and other exhibits. High school and college students help operate the planetarium, as well as members of the Southern Idaho Amateur Astronomers.

The idea for this community observatory was conceived three years ago, and last March Mr. Herrett put his wife in charge of his jewelry manufacturing plant in order to devote all of his own time to the observatory's construction. The two-story building was completed last August. It is located behind the Herrett factory, at 1220 Kimberly Road.

As an experienced amateur telescope maker, Mr. Herrett has constructed 17 reflecting telescopes ranging from six to 12½ inches in aperture. The upper story of the observatory-planetarium houses one of these, the 12-inch Newtonian reflector described on page 341 of the May, 1957, Sky and Telescope. This instrument is about seven feet long, and is on a split-ring mounting. Several smaller telescopes are also available for public observing.

The 20-foot dome is electrically driven, and was shaped from eight separate fiberglass sections. The master mold for the sections, also a Herrett design, may be borrowed by other amateurs for a small fee. With this mold, according to Mr. Herrett, it is possible to build a similar dome for less than $500.



A silhouette cutout at the base of the planetarium dome shows the skyline of Twin Falls, Idaho. Kelker Studio photograph.

A 20-foot planetarium chamber is located on the building's lower floor. The projector was built by Adrian Allen from a Japanese fiberglass fish float, perforated to show the exact locations of the major stars and constellations. The demonstrator may produce such special effects as sunrise, sunset, and the northern lights, through additional apparatus. Along the dome is a skyline cutout of the Twin Falls area. There are also displays of astronomical subjects, such as meteorites, and models of the solar system and Milky Way.

The observatory-planetarium is open to the public three nights each month and by special request at any time. Amateur astronomers visiting the Twin Falls area are always welcome.

MARS OBSERVING PROGRAM

During November the Oklahoma Astronomical Society, the junior group in Tulsa, sponsored a state-wide observing program for Mars. Stations were set up at several locations with 8-, 10-, and 12-inch reflectors, and each observing group, comprised mainly of students, made drawings of the planet. Printed data sheets were used to secure uniformity of the records, which included such information as the magnification and the kind of filter employed.

The program was primarily to teach techniques of planetary observing. We plan other similar projects on a state-wide basis.

CLIFFORD R. RAMSEY
McCain House
University of Oklahoma
Norman, Okla.

Getting Acquainted with Astronomy

Time and the Sky — II

A star that rises at 10 o'clock standard time tonight will rise at about 8 o'clock in the evening one month from now. Similarly, if a star is observed setting at 7 p.m. this evening, it will set about 5 p.m. in a month. Unless they are circumpolar, all stars rise, reach the celestial meridian, and set about four minutes earlier each day, two hours earlier in a month, and one day earlier in a year, according to our clocks that keep mean solar time.

But this would not be the case if our clocks were adjusted to keep time by the stars instead of by the sun. Then the stars would rise, transit, and set at the same time every day, but the sun would not. Suppose a clock running by the stars agreed with the sun on September 21st, showing midnight when the sun was on the other side of the world. However, six months later, on March 21st, with this clock again indicating midnight, it would be broad daylight outside — midday by the sun.

Sidereal Time

It is evident from the foregoing that solar time must be used in civil life, but in every professional observatory there is a clock showing *sidereal time,* which is practically that kept by the stars. The sidereal time reference point, which serves the same function as the sun does in solar time, is the March or vernal equinox, where the celestial equator is crossed by the sun as it moves northward each year.

A *sidereal day* is the interval between two successive transits of the March equinox across the observer's meridian. This day has a length of very nearly 23 hours, 56 minutes, and four seconds of mean solar time. Thus, a sidereal day is three minutes and 56 seconds shorter than a solar day. On a sidereal clock, however, there are 24 hours of 60 minutes each, and a second of sidereal time is 0.99727 as long as a solar second.

It is the motion of the earth in its orbit around the sun that causes the difference between sidereal and solar time. The diagram shows that one exact rotation of the earth will suffice to bring the March equinox back to the meridian, completing a sidereal day, but a slight additional turn, requiring nearly four minutes, is needed to bring the sun back to the meridian to complete a solar day. Thus, there are about $366\frac{1}{4}$ sidereal days (earth rotations) in a year, and exactly one solar day less than this.

The sidereal time at any instant is the sidereal interval that has elapsed since the March equinox was on the meridian, that is, the hour angle of the equinox. If the sidereal time is 2^h, for example, the equinox has moved for two hours, or 30 degrees to the west of the meridian. A sidereal time of 18^h places the equinox on the eastern horizon, just rising, for it has moved 270 degrees from the previous meridian transit.

The great usefulness of sidereal time is in locating stars with an equatorially mounted telescope. But this is a local time, differing from the sidereal time for any other longitude; there is no sidereal time analogous to standard time. Therefore, the observer must either have a clock running on his sidereal time or must compute its value for use in star finding.

Deriving Sidereal Time

The *American Ephemeris* and other almanacs contain for every day of the year the precise value of the sidereal time on the Greenwich meridian at 0^h Universal time (GST). As this value differs for the same date from year to year, it must be taken from an almanac for the current year. The following values from the *American Ephemeris* for 1959 have been rounded to tenths of a minute:

GREENWICH SIDEREAL TIME AT 0^h UT – 1959

Jan.	2	6:43.5	Apr.	2	12:38.4	July	1	18:33.2	Sep.	29	0:28.0
	12	7:23.0		12	13:17.8		11	19:12.6	Oct.	9	1:07.5
	22	8:02.4		22	13:57.2		21	19:52.1		19	1:46.9
Feb.	1	8:41.8	May	2	14:36.6		31	20:31.5		29	2:26.3
	11	9:21.2		12	15:16.1	Aug.	10	21:10.9	Nov.	8	3:05.7
	21	10:00.7		22	15:55.5		20	21:50.3		18	3:45.2
Mar.	3	10:40.1	June	1	16:34.9		30	22:29.8		28	4:24.6
	13	11:19.5		11	17:14.4	Sep.	9	23:09.2	Dec.	8	5:04.0
	23	11:58.9		21	17:53.8		19	23:48.6		18	5:43.4
Apr.	2	12:38.4	July	1	18:33.2		29	0:28.0		28	6:22.9

Since 10 days separate the successive dates in this table, it is easy to interpolate for other dates, the daily change averaging about 3.94 minutes. For instance, to find the GST of 0^h UT on January 15, 1959, add 3×3.94 to 7:23:0, the value for January 12th in the table. This gives 7:34.8.

To find our local sidereal time (LST) we have only to add three numbers to the Greenwich sidereal time at 0^h UT we have just found:

$$\text{LST} = \text{GST} + A + \text{Local Time} + B.$$

A is a small correction, depending on the observer's geographical longitude, and is taken from the accompanying correction table. For example, if the longitude is 112° 30′ west, or 7 hours 30 minutes in time, the value of the correction is seen to be 1.2 minutes. A is a constant for each station, and is negative for east longitudes.

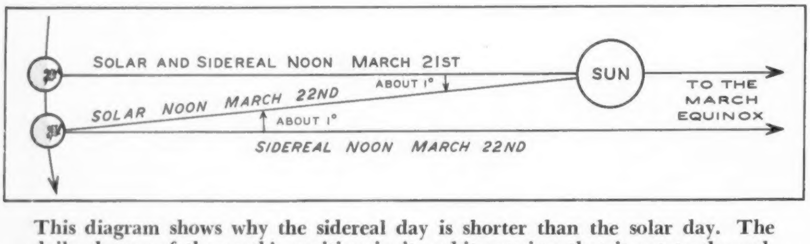
CORRECTION TABLE FOR SIDEREAL TIME

0:00		8:14		16:45	
	0.0		1.4		2.8
0:19		8:50		17:21	
	0.1		1.5		2.9
0:55		9:27		17:58	
	0.2		1.6		3.0
1:32		10:03		18:34	
	0.3		1.7		3.1
2:08		10:40		19:11	
	0.4		1.8		3.2
2:45		11:16		19:48	
	0.5		1.9		3.3
3:21		11:53		20:24	
	0.6		2.0		3.4
3:58		12:29		21:01	
	0.7		2.1		3.5
4:34		13:06		21:37	
	0.8		2.2		3.6
5:11		13:42		22:14	
	0.9		2.3		3.7
5:47		14:19		22:50	
	1.0		2.4		3.8
6:24		14:55		23:27	
	1.1		2.5		3.9
7:01		15:32		23:59	
	1.2		2.6		
7:37		16:08			
	1.3		2.7		
8:14		16:45			

NOTE: If the mean time interval with which this table is entered is one of the tabulated values, use the larger correction.

The next term needed is the local mean time. This is found by adding to the standard time the longitude difference between your station and the central meridian of your time zone. This difference is to be expressed in time, and is negative for places west of the standard meridian. Thus, if the Mountain standard time (seven hours slow of UT) is 8:22 p.m. at a station in longitude 7 hours 30 minutes west, the local mean time is $8{:}22 - 0{:}30 = 7{:}52$ p.m., or 19:52 in 24-hour reckoning.

The last term in the sum is needed to convert the interval elapsed since 0^h — in our example 19:52 — from a mean time



This diagram shows why the sidereal day is shorter than the solar day. The daily change of the earth's position in its orbit requires that it rotate through nearly 361 degrees to bring the sun back to the meridian. Adapted from a diagram in "Astronomy," by Robert H. Baker, published by Van Nostrand.

interval to a sidereal time interval. Using the correction table again, we find that B is 3.3 minutes.

Therefore the local sidereal time corresponding to 8:22 p.m. MST on January 15, 1959, in longitude 112° 30′ west, is

$$7{:}34.8 + 1.2 + 19{:}52 + 3.3 = 27{:}31.3,$$

or 3:31.3 when we discard the excess 24 hours in the answer.

(To be continued)

QUESTIONS... FROM THE S+T MAILBAG

Q. Why is Mercury at the time of greatest elongation sometimes as much as 28 degrees or as little as 18 degrees from the sun?

A. The orbit of Mercury is much more elongated an ellipse than is that of the earth. Hence, when Mercury is near aphelion (43 million miles from the sun), it can be a much larger maximum angular distance (elongation) from the sun than when the planet is near perihelion (29 million miles).

Q. What is a rich-field telescope?

A. It is a short-focus instrument (generally f/4 or less) with great light-gathering power and wide field of view. Used at low magnification, it provides spectacular views of Milky Way fields.

Q. What is meant by Bayer designations of stars?

A. The German astronomer Johann Bayer in 1603 introduced a system of names, still in common use, for the brighter naked-eye stars. It consists of Greek (or sometimes Roman) letters, followed by the genitive form of the Latin name of the constellation. Thus Aldebaran is α Tauri, and Rigel is β Orionis. Often, but not always, the brightest star in a constellation bears the letter α.

Q. How precisely should a telescope mirror be figured to show fine lunar and planetary detail?

A. Generally 1/10-wave accuracy is sufficient, as atmospheric turbulence usually limits the amount of detail visible. Furthermore, with the average telescope, air currents within the tube, optical misalignment, and imperfect eyepieces render higher accuracy useless. Experienced observers with carefully designed telescopes can profitably use optics figured to 1/20 wave or better, if seeing is excellent.

Q. What is meant by the time of upper culmination of a star?

A. This is the moment at which the star crosses the half of the observer's meridian that includes the north celestial pole, zenith, and south celestial pole. Twelve sidereal hours later, the same star will be at lower culmination, when it crosses the other half of the meridian, that including the nadir. W. E. S.

OBSERVING THE SATELLITES

Launching Site for Polar Orbits

At Cape Canaveral, Florida, down-range safety requirements prevent the launching of artificial satellites into orbits inclined much more than 50 degrees to the earth's equator. This limitation is bypassed at a new West Coast missile firing range, whose launching site is at Vandenberg Air Force Base, in southern California, and which includes tracking installations along 500 miles of the Pacific coastline. While the range is primarily for military purposes, its facilities will be available for satellite launchings in the future.

At nearby Point Arguello, a naval missile site is under construction. Both bases will conduct projects assigned by the NASA, and are designed to complement the Atlantic missile range at Cape Canaveral and the rocket launching site at White Sands, New Mexico.

From these stations, satellites can safely be fired southward into orbits that pass over both poles of the earth. Because of the earth's rotation, the launching direction must actually be west of south, rather than along a meridian, to achieve a true polar orbit. A new Air Force project calls for reconnaissance satellites moving in polar orbits at comparatively low altitudes, with short lifetimes. Details of their instrumentation have not been made public at this writing.

The December Moon Shot

In AMERICA'S fourth attempt to establish a lunar probe, Pioneer III was launched by the U. S. Army from Cape Canaveral, Saturday, December 6, 1958, at 12:45 a.m. Eastern standard time. The 60-ton four-stage rocket was intended to carry a 12.9-pound conical instrument package to the moon's vicinity. Burnout occurred 3.7 seconds too soon for the first stage, a modified Jupiter intermediate-range ballistic missile, and consequently when the payload was released it had a velocity of 24,000 miles per hour, about 1,000 less than intended. It was also three degrees off course.

The lowered velocity caused the vehicle to follow a relatively small elliptical orbit (Sky and Telescope Special Supplement, November, 1958). The maximum altitude reached was about 65,000 miles, as against 71,300 miles (revised value) by the Air Force's Pioneer I last October.

During the descent of Pioneer III, radio contact was incomplete, for the two principal tracking stations, at Camp Irwin, California, and at Mayaguez, Puerto Rico, were on the far side of the earth from the vehicle and could not hear the constant signals from its one-pound transmitter. Preliminary calculations announced by the National Aeronautics and Space Administration indicate that the flight lasted 38 hours, the probe disintegrating in the dense lower atmosphere over French Equatorial Africa, in approximately latitude 16°.4 north, longitude 18°.6 east.

Despite failure to achieve its most publicized purpose, the lunar shot had scientific value. Pioneer III's two Geiger counters telemetered to earth extensive information about the recently discovered zone of intense radiation surrounding the earth. This is now generally known as the Van Allen radiation belt, after Dr. James A. Van Allen, State University of Iowa, who has been in charge of cosmic ray experiments with American artificial satellites and space probes.

The Army's Explorer artificial satellites, with which the radiation belt was discovered, penetrated only its lowest regions. Limited information was secured about it from Pioneer I, because of instrumental difficulties, as no readable signals from its Geiger counters were obtained until after the probe had passed through the densest part of the Van Allen belt.

Two new devices incorporated in the December lunar probe were not operative because it never came near enough to the moon. One was a pair of photoelectric sensing devices that were to be triggered by the moon's light and start a television system to observe the lunar surface. The other device was intended to stabilize the instrument package against spin. It consisted of two small weights on wires, wrapped around the payload, to be released in the immediate neighborhood of the moon.

More About Project Rotor

As THIS is being written, word comes of the last-reported observation of the rocket carrier of Sputnik III, or artificial satellite 1958δ1. The final North American sightings were expected to be made on the satellite's southwest-northeast passages early on December 3rd. It crossed over New England at 7 o'clock in the morning, and was picked up by the large radar at Stanford University in California at 9:56 a.m. Eastern standard time. Nothing further has been seen, or observed by radio, and it is presumed that, in accordance with expectations, 1958δ1 is no longer circling the earth.

Throughout the career of the rocket, many observers became familiar with its rapid, rhythmic changes in luminosity, as the elongated body tumbled in its path periodically. This phenomenon was discussed in this department last month, where announcement was made of Project Rotor. This is a co-operative effort to observe the rapid brightness changes of 1958δ1 and other satellites to deduce the direction of the tumble axis and its precession.

The light curve of 1958δ1 normally

consisted of waves several magnitudes in amplitude, with a period of about nine seconds. Among the many reports received, however, several include occasions when the fluctuations temporarily died out, the satellite shining with a steady light during part of its crossing of the sky. This striking effect was observed twice by D. C. Whitmarsh and his associates at State College, Pennsylvania, and has been photographed by R. E. Wallace, of Menlo Park, California.

This brief cessation of brightness variations is easy to account for. The diagram shows a plane mirror, *P*, at the satellite's position in space, reflecting a ray of light from the sun to the observer. Both the incident and reflected rays lie in the same plane, which also contains *N*, the perpendicular or normal to the mirror at the point of reflection.

Then, if we assume the satellite to be a uniformly reflecting long cylinder, it will appear bright to the observer when the long axis lies anywhere in the mirror plane *P*. And if some of the reflection from the satellite is diffuse, it will appear nearly as bright when not exactly in that plane. Therefore, the brightness will seem constant to the observer whenever the satellite is rotating in or nearly in plane *P*.

Although it is difficult to tell exactly when the light intensity is constant, this effect provides an approximate way to determine the instantaneous orientation of the satellite's tumbling axis, from observations at a single site, for the axis must lie along *N*.

At Cambridge, Massachusetts, such an interval of nearly constant brightness for $1958\delta 1$ was observed November 25th by Mr. and Mrs. W. R. Battersby, P. Valleli, and J. Bower. From this it was determined that at 22:03 UT on that date the tumble axis was oriented approximately toward right ascension $15^h\ 55^m$, declination $-45^\circ.7$.

Results of this kind are valuable supplements to Project Rotor, for which the basic procedure is to determine the axis orientation by comparing the times of brightness maxima as seen from widely separated stations. The orientation of *P* is computed for each station, and the orientation of the satellite in this plane is inferred from the differences in the observers' times.

The second diagram shows that the geographical positions of observers who see simultaneous flashes from a specularly reflecting cylinder lie on the intersection with the earth of a cone whose apex is at the satellite and whose axis coincides with the satellite's long axis. This diagram is adapted from a 1957 report by the Smithsonian astronomers R. J. Davis, R. C. Wells, and F. L. Whipple. They suggested that half the surface of a cylindrical rocket be made shiny and the other half diffusely reflecting, to facilitate study of its rotation.

Knowledge of a satellite's spatial orientation is important in interpreting much of its observational data. For example, cosmic ray counts depend on the direction in which the counter is pointing. As Explorer III tumbled around its axis, the measured cosmic ray flux varied in a manner that suggested some 80 per cent of the particles were coming from one direction, according to a Jet Propulsion Laboratory report.

Furthermore, to deduce upper-atmosphere densities from the observed changes in a satellite's orbit as it passes through perigee, we must know its orientation in space. For example, because of insufficient information about the direction of the tumble axis, there is a 20-per-cent uncertainty in air densities determined in this way from Explorer IV by G. F. Schilling and C. A. Whitney, Smithsonian Astrophysical Observatory.

Observations of the brightness changes of conspicuous satellites launched in the future are especially important during their first days in orbit. Early changes in the light-reflection behavior indicate the manner in which such a satellite's original longitudinal spin is changing to a tumbling rotation. Reports of such observations should be submitted to the undersigned.

British Contributions

MANY ingenious devices have been proposed to help artificial satellite observations, from complex, nearly automatic systems to simple aids for the visual observer. Intermediate between these extremes is an instrument described in a recent issue of *Nature* by Peter Willmore, a physicist at University College, London. It is a relatively simple and inexpensive photoelectric device for determining satellite positions with high accuracy.

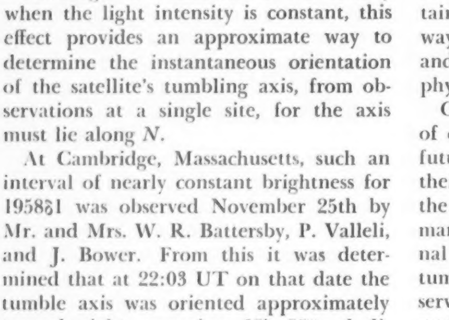
At the focus of a suitable telescope Dr. Willmore places a plate pierced by narrow slits, with a photomultiplier tube behind it. As the image of the satellite passes each slit, an electrical pulse is generated, and is recorded together with time signals. A 5-inch objective enables the position of the satellite to be determined with an accuracy of about two seconds of arc. This high precision may allow study of small periodic perturbations of artificial satellite orbits.

A valuable 87-page discussion of the first two Soviet artificial satellites has recently been published in England, in No. 1,252 of the *Proceedings* of the Royal Society, Series A. Most of the 16 reports deal with radio and radar observations, and with methods of orbit computation. Noteworthy is D. G. King-Hele's contribution containing a concise yet thorough explanation of how a satellite's motion is affected by air drag and by the oblateness of the earth.

Bibliography

The Research Station for Satellite Observation is attempting to compile a complete bibliography of published works dealing with artificial satellites. Because the literature is very scattered, valuable contributions are easily overlooked, and authors in this field are invited to send reprints of their papers to the undersigned.

MARSHALL MELIN
Research Station for Satellite Observation
Harvard Observatory
Cambridge 38, Mass.



Left: If a satellite is tumbling in the plane P, sunlight reflected from it will appear steady to an observer at the position shown here.

Right: Observers who simultaneously see flashes from a cylindrical body are located where a cone whose apex is the satellite intersects the surface of the earth.

ARGENTINE ASTRONOMICAL ASSOCIATION FORMED

The first scientific meeting of its kind in Argentina was attended by professional astronomers on November 7-9, 1958, at the Felix Aguilar Observatory, University of Cuyo, San Juan. The program consisted of 17 papers, three general reports, and 10 progress reports.

An important outcome was the founding of the Argentine Astronomical Association (Asociacion Argentina de Astronomia). The officers are B. H. Dawson, president; J. J. Nissen, vice-president; C. Jaschek, secretary; J. Landi-Dessy, treasurer; and C. U. Cesco and J. L. Sersic, councilors.

QUESTAR NEWS *January, 1959*

Mr. Arthur C. Clarke writes us from his home in Ceylon, in a letter dated October 6, 1958: "I had hoped to have some pictures to show you by now. However, I have not been able to beat the ones of the Davises you've published, and absolutely filthy monsoon weather has prevented me from having a crack at Mare Imbrium this week. Nevertheless, I have obtained lunar shots from here in the middle of Colombo, with my new Questar, far better than anything I ever imagined could be done with nonobservatory gear, and am completely delighted with the results.

"I've shown my photos of the moon to dozens of people, and they and the telescope have made a great impression.

"By the way, sooner or later you are going to have to start a Questar Newsletter for your customers, to deal with queries and to report new uses and achievements. What do you think?"

Why, bless you, Mr. Clarke — we think it's a wonderful idea! The best part of it is that we can make our monthly page in "Sky and Telescope" the newsletter, and then, when that old devil deadline rolls around about a month before each ad appears, we can surely think of something to say to get another page started.

So hooray for Mr. Clarke, and our thanks to him. We propose to run this page quite informally, and over our own signature, so that when we pull a boner (and, oh boy, it happens!) you'll know exactly who's responsible. Me, that's who!

You see how this works out? We shift the blame to the distinguished Arthur Charles Clarke, F.R.A.S., former chairman of the British Interplanetary Society, who is a formidable fellow indeed. He is "Holiday" magazine's science expert, and this winter he is lecturing in the United States. His latest book, "Voices Across the Sea," Harpers, 1958, is all about the laying of the first Atlantic cable, and his other nonfiction works are "Interplanetary Flight," "Exploration of Space," and "Making of a Moon." The fact that he is a physicist has no doubt contributed to the delightful maturity of his many science-fiction works.

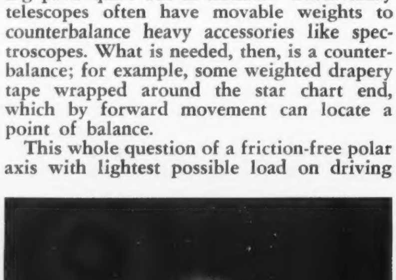
A story on the moon in the "Ceylon Observer" of October 16th carries two of the excellent moon shots he mentions, and he raises two points with us. First: the mirror and shutter of his Exakta camera "let go with a heck of a clunk." He wonders if this is true of all Exaktas or only his, because his fast terrestrial shots are all blurred by this sudden vibration. He says he waves a black card in front of the open shutter for astronomical shots.

We replied that we think the fault must be in his particular camera since dozens of Exaktas are working well with Questars. The heart of the matter is that the focused cones of rays ought not to move at all on the film during the instant of exposure, even by so much as .0001 inch. The portable Questar weighs less than 7 pounds, but here is an instance where its tube alone might profitably weigh 100 pounds, better to absorb the double jolt of a rough mirror and shutter mechanism. Most modern single-lens reflex cameras have fairly light shutter recoil, and those with self-timer, like the Hexacon, can flip the mirror up a second or two before the shutter releases. An extra-rigid tripod helps, and no loss of dignity is involved in laying a small shotbag over the telescope's barrel for added mass when critical terrestrial work is required. The result is what counts.

His second point is that his Exakta camera is so heavy that the telescope's drive carries

it only when pointed near the zenith — it just skids instead of being carried uphill in other positions. Does this mean that his R.A. drive is loose and needs tightening? Our answer was, probably not. The Exakta is one of the heaviest 35-mm. cameras made, weighing about 2 pounds. To add this to one end of Questar's short tube throws the 5-pound moving parts quite out of balance. Observatory telescopes often have movable weights to counterbalance heavy accessories like spectroscopes. What is needed, then, is a counterbalance; for example, some weighted drapery tape wrapped around the star chart end, which by forward movement can locate a point of balance.

This whole question of a friction-free polar axis with lightest possible load on driving



gear teeth, low tooth pressure and good balance, was considered of the utmost importance by Prof. G. W. Ritchey for high-resolution astrographic work with large instruments. For this reason we set Questar's friction clutch rather lightly. The tighter it is set, the more total friction and greater tooth pressure result, which lead to microscopic jerks and jumps. It is better all around to balance the driven load. Here again, it is a matter of tracking during many seconds with an infinite number of focused ray cones held within .0001 or .0002 inch on the sensitive emulsion. The great optical leverage of a dozen or more feet of focal length can magnify enormously the least faltering of a drive.

Mr. and Mrs. Ralph Davis confirm this point of view. They use a very light clutch and have made little counterbalance arms that attach to the fork arms. This moon shot, taken October 21, 1958, when the moon was pretty low, is on Microfile film, 80x eyepiece projection, exposure 15 seconds. On 8 x 10 prints there is no grain at all, and no evidence of image movement.

It is probably Ralph Davis' care in balancing and focusing his Questar that secures such superb negatives with only 3.5 inches of aperture, while Dorothy Davis will stick to a good negative in the darkroom for hours, making print after print until the right one comes just so.

Only the most intrepid would expect to photograph Mars with anything much smaller than a 12-inch aperture, because a dozen times Questar's light-gathering power ought to be used, and with a red filter, too, to enhance the markings. But nothing daunts Mr. Davis, who sends us this first Mars shot (with complaints about vile weather) and tells us that its chief interest for him is that "it shows how far you can carry this slow-film long-exposure thing if your drive is smooth." This, on slow Microfile, took no less than 24 seconds! "The image was smaller than a pinhead, yet there is still no grain. We are going to try fine-grain color film, which is faster. There was just not enough light for a red filter."

Please bear in mind that we reproduce this photograph of Mars only to illustrate good tracking during 24 seconds on a planet only 19 seconds of arc or less in diameter. The seeing was not fine and no filter was employed. Without doubt there was much air disturbance during this long exposure, so contrary to the usual rule of "fastest film and shortest shot" for planetary work. When large telescopes take thousands of pictures of Mars at favorable oppositions, it is in the hope that some few of them will be by chance secured in a fraction of a second's absolutely perfect seeing, the way we glimpse the fine detail visually. So it may well be that the Davises' fine-grain long-exposure technique, which has worked so well on the extended surface of the moon, may be wholly unsuitable for Mars. At any rate it's an interesting experimental shot.

Next month we shall tell you how dumb we are at arithmetic, and how every Questar is now guaranteed to resolve 0.8 second on the Bureau of Standards test chart that accompanies each instrument.

The Questar telescope costs $995 and may be purchased on the extended payment plan. Literature on request.

Laurence Braymer
President

QUESTAR CORPORATION
New Hope, Pennsylvania

Graphic Time Table of the Heavens — 1959

ON THE FOLLOWING pages is a chart that is a condensed and simple almanac, giving the rising and setting times of the sun, moon, and brighter planets, and much other useful astronomical information. This Graphic Time Table is published annually by the Maryland Academy of Sciences, through whose courtesy it is reproduced here for the 18th year. Separate copies may be obtained from the Maryland Academy of Sciences, 400 Cathedral St., Baltimore 1, Md., for 25¢ each; discount on quantity orders. Large wall charts, 40 by 27 inches, may be ordered for $1.00 folded, $1.50 rolled.

How To Use the Graphic Time Table

Across the top and bottom of the chart are marked the hours from 4 p.m. to 8 a.m.; the days of the year run down the chart. Thus any event, such as a particular sunset, can be read by following the horizontal line for the date to where it intersects the curve marking the event, in this case the sunset curve.

In this way the Graphic Time Table gives the rising and setting times of the sun and moon and the planets Mercury, Venus, Mars, Jupiter, and Saturn; the duration of twilight; and the times when certain stars and other interesting objects transit, that is, cross the meridian. The moon's phases are also indicated.

Small numbers at the left give the Julian day number. These numbers are a consecutive count of the days, beginning in 4713 B.C., so January 1, 1959, is JD 2,436,570. Julian days offer a simple way to find the interval between two dates by a single subtraction, and they are widely used by astronomers, particularly in variable star work. The Julian day number changes at Greenwich noon, or 6 a.m., Central standard time.

Along the midnight line are Roman numerals that indicate the sidereal time at midnight, in other words, the right ascension of a star then at the meridian on the date in question. Running along the midnight line and crossing it is the curve for the equation of time, which shows how much the sun is fast if the curve is to the left of the midnight line, and how much the sun is slow if the curve is to the right of the line. When the sun is fast, it arrives at the meridian before 12 o'clock noon, by the amount shown between the curve and the midnight line.

Small black circles show moonset for the first half of each lunar month, and small open circles, moonrise from full to new moon, for longitude 90° west and latitude 40° north. At longitude 75° west, the moon will rise about two minutes earlier than these times; at longitude 120° west, about four minutes later. Also plotted for the moon each day are little marks or "ticks," placed at the corresponding times for moonrise and moonset at the earth's equator; each tick has a horizontal bar pointing toward the time at 40° north, where the open or black moon circle is located. These marks aid interpolation for latitudes intermediate between the equator and 40° north, and may be used for cautious extrapolation to higher latitudes.

Every curve for the rising and setting of the planets has a "ghost" counterpart to show the planet's rising or setting at the equator. These curves are indicated by the appropriate planet symbols and the letter R for rises and S for sets. For example, the equatorial curve for "Mercury sets" starts in the extreme upper left part of the chart and is labeled on the line for February 15-16.

The scale at the right is for finding rising or setting times of other objects. Set dividers, or a strip of paper, from the index at the center of the scale to the object's declination, north or south (which must be known), and in the direction desired for either rising or setting. Measure this same distance along the midnight line of the chart beginning at the proper right ascension indicated by the Roman numerals. Should this end point fall outside the chart, add to or subtract from the right ascension 12 hours and reset the dividers, using the end of the scale rather than the center index. Through the point established, draw a line parallel to the vernal equinox line on the chart. This will show the time of the rising or setting of the object at latitude 40° north.

There are two errors on the chart: On the February 4-5 line, the arrow for the end of evening twilight should point to the long dashed line, instead of to the curve for "Venus sets," and on September 20-21, Aldebaran is spelled incorrectly.

The Events of a Single Night

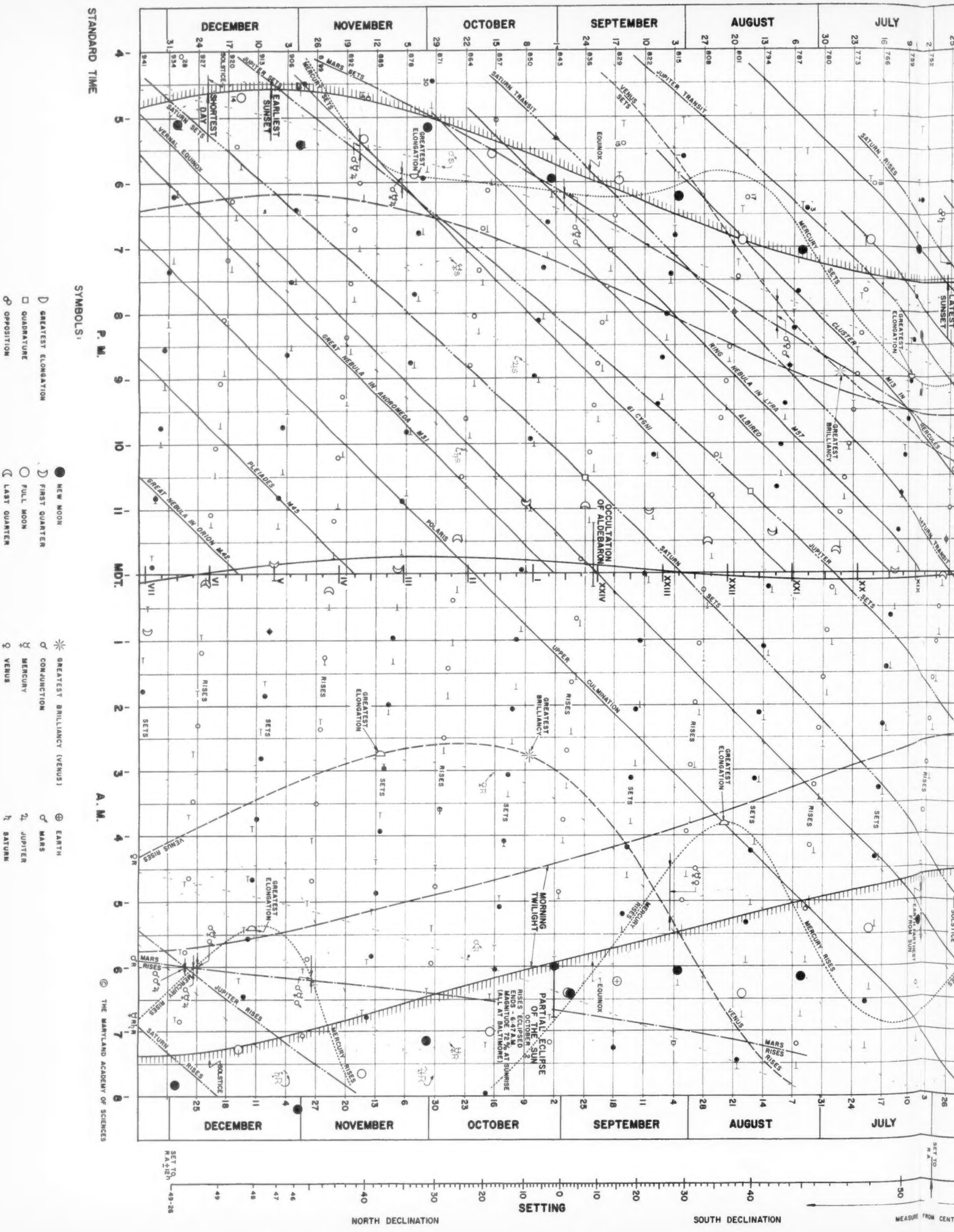
As an example, consider the night of January 1-2 by following the horizontal line for that date across the chart from left to right. The Julian day number is 2,436,570. We read from the chart the time of sunset as 4:44 p.m., and the transit of the vernal equinox as 5:17 — marking 0^h local sidereal time. Venus sets at 5:40, and twilight ends at 6:22. Polaris reaches upper culmination at 7:13; it is then due north and directly above the pole. Mars crosses the meridian at 8:14; other transits are the Pleiades at 9:01, the Great Nebula in Orion at 10:52, and Sirius at midnight. The small circle coinciding with the midnight line indicates moonrise one day before last quarter. At 3:23 a.m. Mars sets, and Jupiter rises 18 minutes later. Mercury rises at 5:41; morning twilight commences three minutes later; and Saturn rises at 6:29. Polaris' lower culmination occurs at 7:11, and sunrise at 7:22 brings the night to a close.

How To Correct for Your Position

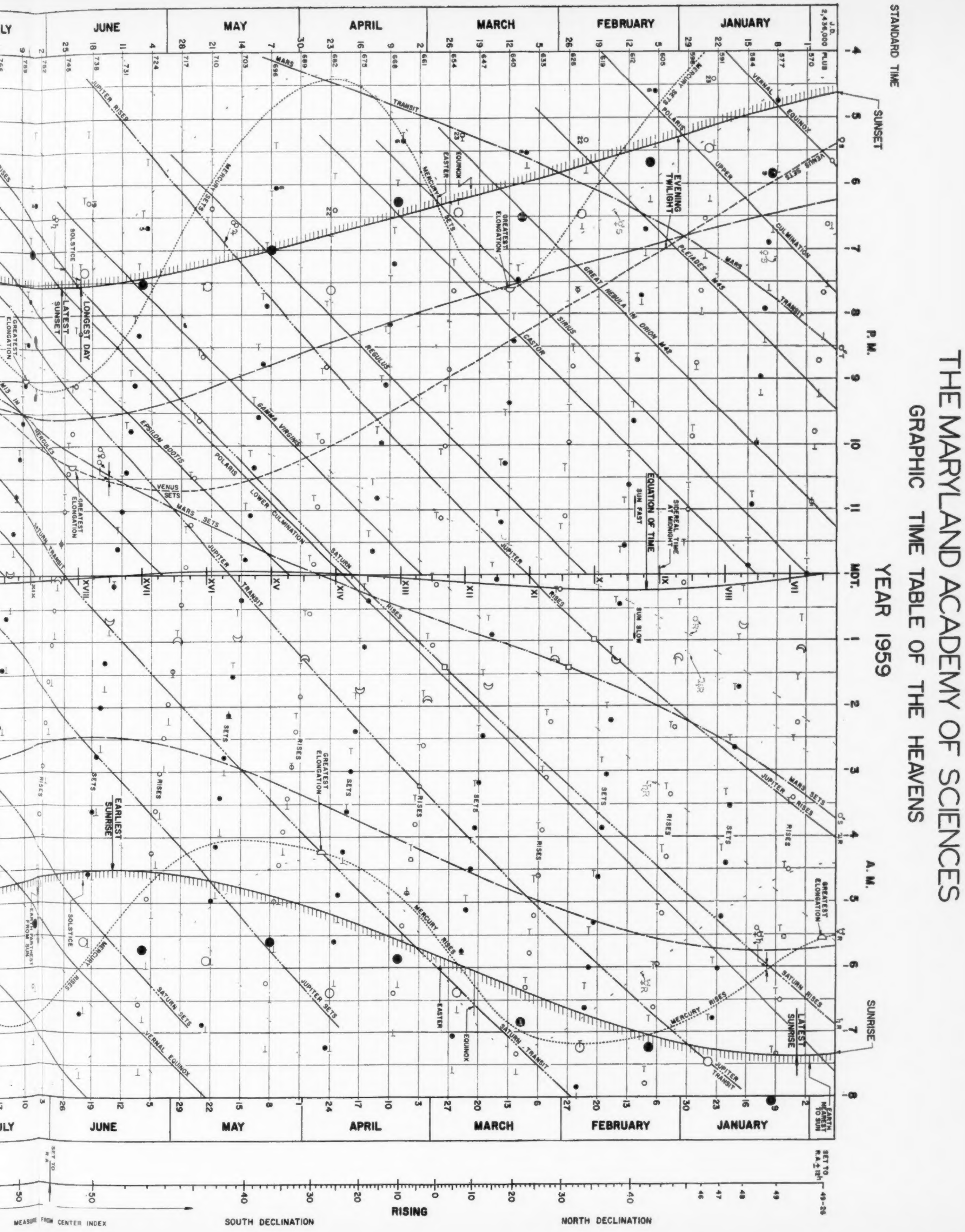
As in all almanacs, the times of rising and setting of the sun, moon, and planets are strictly correct for only one point on the earth's surface — for this chart, latitude 40° north and longitude 90° west. The observer may easily correct for his own position.

Correction for differences in longitude are chiefly to adjust one's local time, shown by the Graphic Time Table, to the standard time of our clocks and watches. This correction depends solely on the distance of the observer east or west of his standard-time meridian, the latter being an even multiple of 15 degrees: 75°, 90°, 105°, and 120° west longitude in the United States. In the following tabulation, in minutes of time, all places with plus corrections are west of the respective standard meridian:

Atlanta	+38	Memphis	0
Bismarck	+43	Miami	+21
Boston	−16	Minneapolis	+13
Chicago	−10	New Orleans	0
Cincinnati	+38	New York	−4
Dallas	+27	Pittsburgh	+20
Denver	0	Rochester	+10
Detroit	+32	St. Louis	+1
Durham	+16	Salt Lake City	+28
El Paso	+6	San Francisco	+10
Helena	+28	Santa Fe	+4
Houston	+21	Seattle	+10
Kansas City	+18	Tucson	+24
Los Angeles	−7	Washington	+8



DECEMBER
NOVEMBER
OCTOBER
SEPTEMBER
AUGUST
JULY
STANDARD TIME
P. M.
A. M.
MDT.
SYMBOLS:
GREATEST ELONGATION
QUADRATURE
OPPOSITION
NEW MOON
FIRST QUARTER
FULL MOON
LAST QUARTER
GREATEST BRILLIANCY (VENUS)
CONJUNCTION
MERCURY
VENUS
EARTH
MARS
JUPITER
SATURN
SHORTEST DAY
EARLIEST SUNSET
LATEST SUNSET
GREAT NEBULA IN ANDROMEDA M31
GREAT NEBULA IN ORION M42
PLEIADES M45
POLARIS
61 CYGNI
ALBIREO
RING NEBULA IN LYRA M57
CLUSTER M13 IN HERCULES
OCCULTATION OF ALDEBARON
UPPER CULMINATION
MORNING TWILIGHT
PARTIAL ECLIPSE OF THE SUN OCTOBER 2
VENUS RISES
MARS RISES
JUPITER RISES
SATURN RISES
MERCURY RISES
SATURN SETS
JUPITER SETS
MERCURY SETS
MARS SETS
VENUS SETS
SATURN TRANSIT
JUPITER TRANSIT
SATURN RISES
VERNAL EQUINOX
EQUINOX
SOLSTICE
© THE MARYLAND ACADEMY OF SCIENCES
SETTING
NORTH DECLINATION
SOUTH DECLINATION


THE MARYLAND ACADEMY OF SCIENCES
GRAPHIC TIME TABLE OF THE HEAVENS
YEAR 1959
STANDARD TIME
SUNSET
SUNRISE
P. M.
A. M.
MDT.
EVENING TWILIGHT
EQUATION OF TIME
SUN FAST
SUN SLOW
SIDEREAL TIME AT MIDNIGHT
LONGEST DAY
LATEST SUNSET
EARLIEST SUNRISE
LATEST SUNRISE
VERNAL EQUINOX
SOLSTICE
EASTER
EQUINOX
GREATEST ELONGATION
EARTH NEAREST TO SUN
EARTH FARTHEST FROM SUN
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
J.D. 2,436,000 PLUS
SET TO R.A. ± 12h
RISING
SOUTH DECLINATION
NORTH DECLINATION
MEASURE FROM CENTER INDEX

OBSERVER'S PAGE

Universal time (UT) is used unless otherwise noted.

Wanted: Amateur Observations of CE Cassiopeiae

AMATEUR ASTRONOMERS with experience in observing variable stars can make an important contribution in the coming year to the problem of the variable double star CE Cassiopeiae. A telescope of at least 12-inch aperture will be required for this work.

CE Cas is a close double star, both of whose components are Cepheid variables with periods near five days. Because these two stars, together with a third Cepheid, CF Cas, belong to the same galactic cluster (NGC 7790), and because all three have slightly different periods, they are of great interest in stellar evolution.

As components **a** and **b** of CE Cas are separated by only 2.3 seconds of arc, it is very difficult to study them individually. Their combined light has been measured photoelectrically by Allan R. Sandage of Mount Wilson and Palomar Observatories, and by me at Harvard, but these observations cannot be used unless the period of each component is known with high accuracy. Periods determined visually in 1947, by G. A. Starikova with the 16-inch refractor of the Abastuman Astrophysical Observatory, are not sufficiently accurate to indicate how many brightness cycles of each star occurred since then.

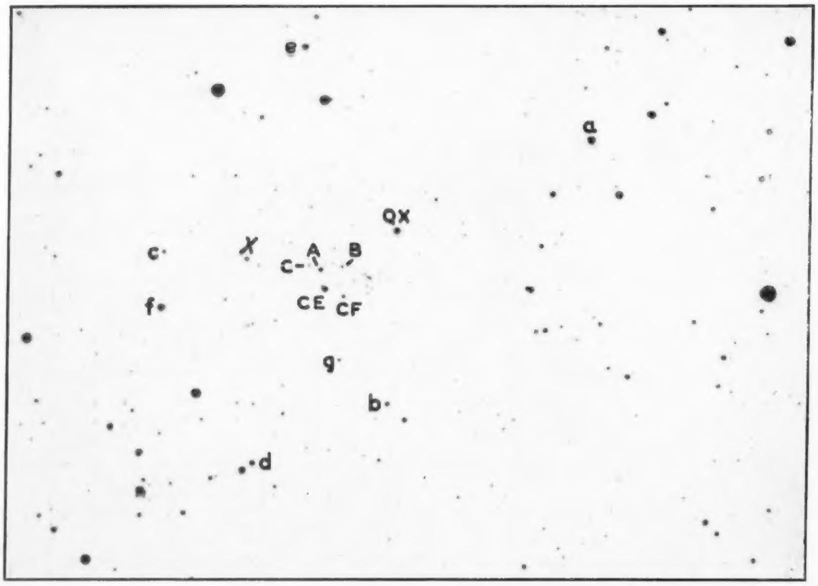
The observations desired on each night are these. First, select a low-power eyepiece that will only show CE Cas as single, and estimate the combined magnitude of the pair.

Second, with a power preferably 300x or more, note whether the **a** or **b** component of CE Cas is the brighter; then, if possible, estimate the magnitude difference between the two stars. It is particularly important to record the times at which the two components appear to be of equal brightness. For such a close pair, the apparent relative brightness of the stars will depend on their relative orientation. The line joining the two stars should be parallel to the line joining the observer's eyes, so that the stars are seen exactly to the right and left of each other.

Probably any ocular that will split the double will have too small a field to allow convenient direct comparisons of the individual components with the sequence stars. If, however, such comparisons can be made, they are highly desirable.

Occasional observations of the brightness of the star *X* should also be made. Because the comparison stars are all bluer than CE Cas, there is a possibility of systematic errors depending on star colors. Hence estimates of the reddish star *X* will indicate what correction, if any, is needed to make your magnitudes agree in color with the photoelectric **V** magnitudes.

The star marked QX on the print is the variable QX Cas, which appears to be of the eclipsing type, but its period is uncertain. At maximum it is about 0.15



A field chart of CE Cassiopeiae, to a scale of 9.4 minutes of arc per inch, with south above. The 1950 position of this variable is 23^h 55^m 37^s, $+60°$ $55'.9$. CE Cas is not resolved, but component "a" is east of "b" and nearer to CF Cas. Visual magnitudes for comparison stars are: A, 11.08; B, 12.15; C, 12.47; a, 9.84; b, 10.91; c, 11.42; d, 10.61; e, 10.34; f, 9.89; g, 11.65. The cluster NGC 7790 around CE Cas is plotted 1.2 minutes of right ascension too far west in the Skalnate Pleso "Atlas of the Heavens." Harvard Observatory photograph.

magnitude brighter than **e**, at minimum about 0.3 fainter than **e**. Visual estimates of QX Cas are not as important as they are for the components of CE Cas.

Finally, because of their relatively short periods, the components' magnitudes should be estimated on as many consecutive nights as possible, rather than having the same number of observations spread out over a month. Don't observe if seeing is so bad the double star cannot be resolved. But a report of a partly resolved observation, with an estimate of which component is the brighter, will have some value.

I shall be glad to answer questions about this program from serious observers who have large enough instruments.

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Harvard Observatory
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COMET BURNHAM-SLAUGHTER

The faint and distant comet discovered at Lowell Observatory on September 7, 1958 (page 22, November issue), is gradually brightening, and during January should be within reach of large amateur telescopes, as it moves from Vulpecula across eastern Cygnus.

The orbit of Comet 1958e has been calculated by M. P. Candy in England, on the assumption that the path around the sun is a parabola. He finds that the comet will be closest to the sun on March 11, 1959, but the separation will not become less than 151 million miles. The comet's orbital motion is direct — that is, in the same sense as that of the planets — in a plane inclined 61 degrees to the ecliptic.

Mr. Candy has calculated an ephemeris, which is given here in part. At 10-day intervals, for 0^h Universal time, the right ascension and declination of the comet (1959.0 co-ordinates) are: **January 2, 21^h**

Comet 1958e, from a 63-minute exposure by Elizabeth Roemer with the Naval Observatory's 40-inch reflector at Flagstaff, Arizona, on November 10, 1958. The scale is about five seconds of arc per millimeter. U.S. Navy photo.

$00^{m}.7$, +24° 37′; **12,** $21^{h}\ 15^{m}.5$, +27° 30′; **22,** $21^{h}\ 32^{m}.9$, +30° 52′. **February 1,** $21^{h}\ 53^{m}.5$, +34° 40′; **11,** $22^{h}\ 18^{m}.1$, +38° 55′; **21,** $22^{h}\ 47^{m}.9$, +43° 31′. **March 3,** $23^{h}\ 24^{m}.8$, +48° 14′; **13,** $0^{h}\ 11^{m}.0$, +52° 43′; **23,** $1^{h}\ 08^{m}.3$, +56° 23′.

According to Mr. Candy, the approximate visual magnitude will be 12.9 at the beginning of this interval and 12.1 at the end. This is in agreement with Elizabeth Roemer's estimate of about 14 for the visual magnitude in mid-November. At that time, the comet was easily visible as a nebulous blob in the 40-inch reflector of the U. S. Naval Observatory's Flagstaff station, but could not be seen in that instrument's 5-inch finder. The photographic magnitude of the nuclear region of the comet, as estimated by Dr. Roemer from short-exposure plates, was 17.0 on September 14th and 16.5 on November 10th.

Comet Burnham-Slaughter, although it will not become a conspicuous object, will probably be observable photographically with very large telescopes until 1960, according to Dr. Roemer.

DEEP-SKY WONDERS

PERHAPS the question most often asked in mail addressed to this column is, "Can you suggest a useful amateur observing handbook?" Unfortunately, the answer is "No."

Relatively speaking, the amateur of a century ago was better off than we are today. He had available the *Celestial Cycle* by Admiral W. H. Smyth, in which were colorful descriptions of hundreds of sky wonders within the reach of a 6-inch telescope. Smyth had observed the objects himself, and his accounts had the sincerity and warmth of personal experience.

Later, T. W. Webb did much the same thing in his *Celestial Objects for Common Telescopes,* the last edition of which came out in 1917. Even though it is out of date, it is probably still the best amateur handbook to be found.

Other books that are useful are *Astronomy with an Opera Glass* by Garrett P. Serviss, and William Tyler Olcott's *Field Book of the Skies.* The latter has recently been revised, but this edition is not particularly adapted for use at the telescope.

The amateur of today must delve into cold and factual catalogues; he must convert mere columns of numerical data into the warm human experience that is stargazing. And the catalogues themselves are often difficult to procure, out of date, or out of print.

The nearest thing to an up-to-date handbook is Norton's *Star Atlas.* The brief list of interesting objects on the back of each chart is ideal for the beginner, though the serious observer soon runs through the 500 objects listed. Perhaps the most complete work now available is the Skalnate Pleso *Atlas Coeli Catalogue.* Despite its lack of descriptive notes, which are really the lifeblood of an amateur handbook, it is extremely useful for the advanced amateur. It reprints Shapley's catalogues of globular and open clusters, has a useful double star section, and includes long lists of planetaries, variable stars, nebulae, and galaxies.

For the amateur who wishes more extensive information, there are many catalogues that are available at observatories, sometimes at public libraries, and even from one's local astronomy club. For galaxies, a standard reference is *A Survey of the External Galaxies Brighter than*

the Thirteenth Magnitude, by Harlow Shapley and Adelaide Ames, which was published in 1932 as Vol. 88, No. 2, of the Harvard *Annals,* but is now out of print. It gives positions for the epoch 1950, photographic magnitudes, angular dimensions, and types.

Shapley's catalogues of star clusters appeared in his book of 1930, *Star Clusters.* More recent is Helen Sawyer Hogg's *A Bibliography of Individual Globular Clusters,* which appeared in 1947 as Vol. 1, No. 20, of the *Publications* of David Dunlap Observatory. It contains a list of all known globulars, with many references.

Planetary nebulae are listed and illustrated by H. D. Curtis in Vol. 13 of the *Publications* of Lick Observatory (1918). The current register of variables is the Moscow *General Catalogue of Variable Stars,* described on page 63 of last month's issue. The AAVSO publishes a listing of the 500 or so variable stars it observes.

The standard work on double stars is still R. G. Aitken's *New General Catalogue of Double Stars* (1932). Unfortunately it lists only stars north of declination −30°, and does not include data later than 1927. For binaries in rapid motion, the descriptions in Aitken may differ confusingly from what is seen in the telescope. However, P. Muller has published predictions to 1970 of the position angles and separations of 304 binary systems, in *Journal des Observateurs, 36,* 61-105, 1953.

Galactic nebulae are thoroughly summarized in S. Cederblad's *Studies of Bright Diffuse Galactic Nebulae,* a publication of Lund Observatory in 1946. It is especially useful for the astrophotographer, as a small fast camera can record most of these objects. Dark nebulae are listed in E. E. Barnard's *A Photographic Atlas of Selected Regions of the Milky Way.*

Useful as all these catalogues are, there remains a great need for a new amateur handbook, but this should not be a mere compilation from other writings. Instead, like Smyth and Webb, its author should reobserve all the objects himself and write new descriptions. The work would be tremendous, but the handbook, if properly done, could be standard for decades to come.

The amateur who enjoys deep-sky observing has many attractive projects open, even if he does not intend to produce a handbook. For example, he might systematically reobserve all of the Messier objects, recording a careful description of each in his logbook. Some amateurs may prefer to write each description on a separate filing card, as this makes it very easy to collate all the observations of the same object.

WALTER SCOTT HOUSTON
Rte. 3, Manhattan, Kans.

SUNSPOT NUMBERS

The following American sunspot numbers for October, 1958, have been derived by Dr. Sarah J. Hill, Whitin Observatory, Wellesley College, from AAVSO Solar Division observations.

October 1, 197; **2,** 209; **3,** 187; **4,** 187; **5,** 142; **6,** 99; **7,** 103; **8,** 79; **9,** 113; **10,** 127; **11,** 115; **12,** 128; **13,** 149; **14,** 142; **15,** 180; **16,** 216; **17,** 239; **18,** 202; **19,** 207; **20,** 168; **21,** 163; **22,** 214; **23,** 169; **24,** 190; **25,** 182; **26,** 168; **27,** 164; **28,** 163; **29,** 152; **30,** 169; **31,** 220. Mean for October, 165.9.

Below are observed mean relative sunspot numbers from Zurich Observatory and its stations in Locarno and Arosa.

November 1, 217; **2,** 201; **3,** 174; **4,** 175; **5,** 138; **6,** 131; **7,** 98; **8,** 114; **9,** 85; **10,** 89; **11,** 76; **12,** 84; **13,** 91; **14,** 93; **15,** 90; **16,** 90; **17,** 72; **18,** 67; **19,** 92; **20,** 94; **21,** 108; **22,** 131; **23,** 142; **24,** 161; **25,** 188; **26,** 224; **27,** 243; **28,** 258; **29,** 271; **30,** 254. Mean for November, 141.7.

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BOOKS AND THE SKY

EXPLORING THE DISTANT STARS

Clyde B. Clason. G. P. Putnam's Sons, New York, 1958. 384 pages. $5.00.

ALTHOUGH this fine book is designed for the novice and the layman, all who teach astronomy in any form can gain much by reading it. The author has turned a mirror on our science and has revealed the vexing complications, the inconsistencies, and the vaguenesses that together raise such a barrier before pupils.

This reviewer knows of no other book that performs so great a service for us as an extra dividend to its fulfillment of the author's original purpose. He seeks only to write of the stars in a way that anyone can understand, and to explain astronomical concepts in everyday language. This is accomplished without any talking down, and Mr. Clason does not shy away from a complex problem in astrophysics if he feels the reader should know something about it.

He has realized that a volume of reasonable size cannot cover all phases of astronomy in detail. Therefore, while the planets are briefly described, stellar astronomy occupies most of the book. This seems desirable, as there have been numbers of recent books on the solar system, including several devoted to particular planets. Thus, the book belongs in every amateur's and student's library to remind him that we have acquired considerable knowledge of the ways of stars and galaxies.

Mr. Clason does not belittle the science. He is matter of fact in everything that he writes, and demonstrates to those who already know most of what he is talking about how confusing such knowledge can appear to the uninitiated. Here is an example.

On page 57 are listed some names of stars taken at random from the star index of Otto Struve's book, *Stellar Evolution*. Mr. Clason lists:

"Alcyone, Algol, Alpha Andromedae, Antares, 47 Andromedae, Pi Aquarii, Alpha Aquilae, Epsilon Aurigae, Zeta Aurigae, RW Aurigae, BD +20° 2465, BD −8° 4352, Barnard 10, i Bootis B, Boss 1985, RZ Camelopardalis, SV Camelopardalis, U Cephei, b^2 Cygni, f^1 Cygni, V367 Cygni, V444 Cygni, 61 Cygni, Nova Cygni, HD 117555, Iota Herculis, u Herculis, Nova Herculis, SX Hydrae. . . ."

How many teachers of freshman courses in astronomy realize the bewilderment that these names, glibly spoken in the course of complicated explanations, induce in their students? Mr. Clason meets the challenge:

"But let's not give up so easily. The bewildering jumble of Greek and Roman, upper and lower case, single and double letters, figures, superscripts and mysterious abbreviations is really quite solvable. All we need to do is to break it down into its separate parts. These are:

Proper names.
Greek letters.
Roman letters.
Figures.
Double letters.
Superscripts and hyphenated designations.
Letters at end of star name.
Prefixes.
Catalog designations."

The explanation that follows this list gives the necessary details in each case (including the single-letter R to Z variable stars), and then there is a brief introduction to star catalogues.

Some chapter headings indicate the popular manner in which each subject is approached. For instance, Part III of the book is entitled, "Stars in Action," and has the following chapter headings:

Portrait of the Sun; Showpieces of the Sky; Light and Heat; Giants and Dwarfs; Double, Double Toil and Trouble; Stars on a Binge; Lighthouses in Space; They Blow Their Tops; Stars in Society; Star Dust.

It is inevitable, of course, that the gen-

eral writer has a few false impressions about a science like astronomy. But Mr. Clason seldom puts these on paper. On page 72 he says, in an otherwise correct explanation, that a star clock lags behind a sun clock, whereas it actually gains nearly four minutes a day.

On page 235 he is incorrect in stating that the companion of Sirius was the first white dwarf discovered. Many years before the first observation of Sirius B, the star o^2 Eridani B was seen; it was recognized as a white dwarf by H. N. Russell from Harvard spectrum plates, before anyone had observed the spectrum of Sirius B.

Mr. Clason has used an old period-luminosity curve for Cepheid variables in the table on page 254, apparently overlooking the fact that the absolute magnitude values for classical Cepheids have been changed.

The appendix contains a long list of references, including many recent articles in astronomical publications. Mr. Clason keeps his reading, *and* his comprehension, right up to date, and every subject of current interest is covered in this book. I can recommend it to the many readers of Sky and Telescope who write us long lists of questions about modern astronomy, or who want to know where someone has put into popular language the multitude of discoveries of the last few years.

C. A. F.

FRANK'S BOOK OF THE TELESCOPE

Charles Frank, 67-73 Saltmarket, Glasgow C. 1, Scotland, 1958. 132 pages. 5s 6d.

SELECTING a first telescope presents a complicated problem to the newcomer, especially if he is attempting to discover the heavens alone, and not with the help of members from a local astronomy club. As stated on its cover, *Frank's Book of the Telescope* is a guide to instruments for the amateur astronomer, intended to assist him over the first hurdles.

It is refreshing indeed to read a book on instruments in which the largest recommended diameter is six inches, and in which the versatility of small war-surplus refractors is well presented, since most beginners are overly concerned with size.

The amount of information contained in this small volume of 132 pages is truly amazing. Careful condensation has enabled the subject to be broadly treated, from light and the function of lenses to catadioptric systems and the making and mounting of a reflecting telescope. However, this is not a book on telescope making – although it tells how to assemble a reflector once you have obtained a mirror.

Although the types of war-surplus equipment available to us differ somewhat from the British ones illustrated, most items are sufficiently similar for the book to be useful to American amateurs.

Eyepieces are another subject in which the beginner often feels lost. Here there are 11 pages of information about them.

The chapter on specialized instruments contains much information on transit telescopes, meridian circles, and the like. Cassegrainian and Gregorian telescope forms are treated, and three pages are devoted to the Springfield mounting, whose design is enlighteningly criticized, though still approved.

The use of a simple altazimuth mounting is well presented. It is usually important that the beginner put his telescope into operation as soon as possible, before he loses his interest in observing. Too many amateur-made mirrors sit idle while a fancy equatorial mounting is built.

This book answers probably 90 per cent of the questions that one might ask about getting a small telescope. It is especially recommended for junior groups.

R. E. C.

NEW BOOKS RECEIVED

Atlas Eclipticalis 1950.0, *Antonin Becvar*, 1958, *Artia*, P. O. B. 790, Prague 2, Czechoslovakia. 34 pages. $17.08.

This is a bound set of 32 large-scale star charts, covering the part of the sky between declinations $+30°$ and $-30°$, thus including the equatorial and ecliptic regions. Star brightnesses are shown by half-magnitude intervals, the smallest symbol indicating stars fainter than 9.75. Visual and spectroscopic doubles are plotted, while variables are marked in a way to show their ranges of

brightness. Each star symbol is colored to indicate spectral type, purple for *O* and *B*, blue for *A*, green for *F*, yellow for *G*, orange for *K*, and red for *M*, *N*, *R*, and *S*.

The atlas contains all stars listed in the Yale zone catalogues. It is thus complete down to about magnitude 9.0, with some additional fainter stars. The few objects in the Boss General Catalogue not contained in the Yale catalogues are also plotted. Double and multiple stars down to combined magnitude 10.0 are included, and fainter multiples that have BD designations. Variables that become at least as bright as visual magnitude 10.0 are shown. The co-ordinates in the atlas are for the epoch 1950.0. The chart scale is two centimeters per degree, and a transparent grid is supplied for reading off star positions.

The atlas is a bound volume measuring 19½ by 26¼ inches, the plotted area of each chart being 17½ by nearly 24 inches. Orders may be placed directly by sending United States funds (check or international money order) to Artia (Czechoslovakian Foreign Trade Corporation for Cultural Commodities) at the address on page 161.

HANDBUCH DER PHYSIK, VOL. 50, Astrophysics I: Stellar Surfaces — Binaries, *S. Flügge*, editor, 1958, *Springer-Verlag*, Heidelberger Platz 3, Berlin-Wilmersdorf, West Germany. 458 pages. DM 98.

The famous German series of treatises on physics and related sciences will contain a number of volumes on astronomy. This one describes spectral classification of normal stars, peculiar spectra, molecular bands in stellar spectra, and the spectra of planetaries and white dwarfs. Separate chapters deal with visual, eclipsing, and spectroscopic binaries. The concluding sections develop the general theory of stellar atmospheres and the theory of planetary nebulae. The nine authors write in English, French, or German.

THE EXACT SCIENCES IN ANTIQUITY, *O. Neugebauer*, 1957, *Brown University Press*. 240 pages. $6.00.

The first edition of this scholarly work, devoted mainly to the history of astronomy, appeared in 1952. It has been brought up to date, with large sections on Egyptian astronomy and on Babylonian planetary theory rewritten. Two appendices have been added, one on Greek mathematics, the other on the Ptolemaic system and its Copernican modification.

STELLAR POPULATIONS, *D. J. K. O'Connell, S. J.*, editor, 1958, *Interscience*. 544 pages. $10.00.

This volume contains the complete proceedings of a conference on stellar populations conducted at the Vatican Observatory in May, 1957, in which 23 astronomers from many countries participated. The summarizing papers are by F. Hoyle, from the physical point of view, and J. H. Oort, from the astronomical point of view.

THE GREEN FLASH AND OTHER LOW SUN PHENOMENA, *D. J. K. O'Connell, S. J.*, 1958, *Interscience*. 192 pages. $6.00.

Eighty photographs in color, all taken at the Vatican Observatory by C. Treusch, S. J., are published in this book, together with numerous black-and-white pictures. Astronomical telescopes that could be pointed to the horizon were used to procure this unprecedented series of pictures of the green flash, the red rim, and other meteorological phenomena involving the sun, moon, and planets when they rise or set.

THE OBSERVER'S HANDBOOK 1959, *Ruth J. Northcott*, editor, 1958, *Royal Astronomical Society of Canada*, 252 College St., Toronto 2B, Ontario. 85 pages. 75 cents, paper bound.

This is the 51st annual edition of this valuable aid for the amateur astronomer. Phenomena are listed month by month, and include data on the sun, moon, planets, Jupiter's satellites, and meteor showers for 1959. There are tables of the rising and setting times for the sun and moon, variable star predictions, and compilations of information on double stars, clusters, nebulae, and galaxies suitable for amateur observing. Included also is a list of the 286 stars brighter than magnitude 3.55, with colors, spectra, motions, distances, and absolute magnitudes.

GLEANINGS FOR ATM's

CONDUCTED BY ROBERT E. COX

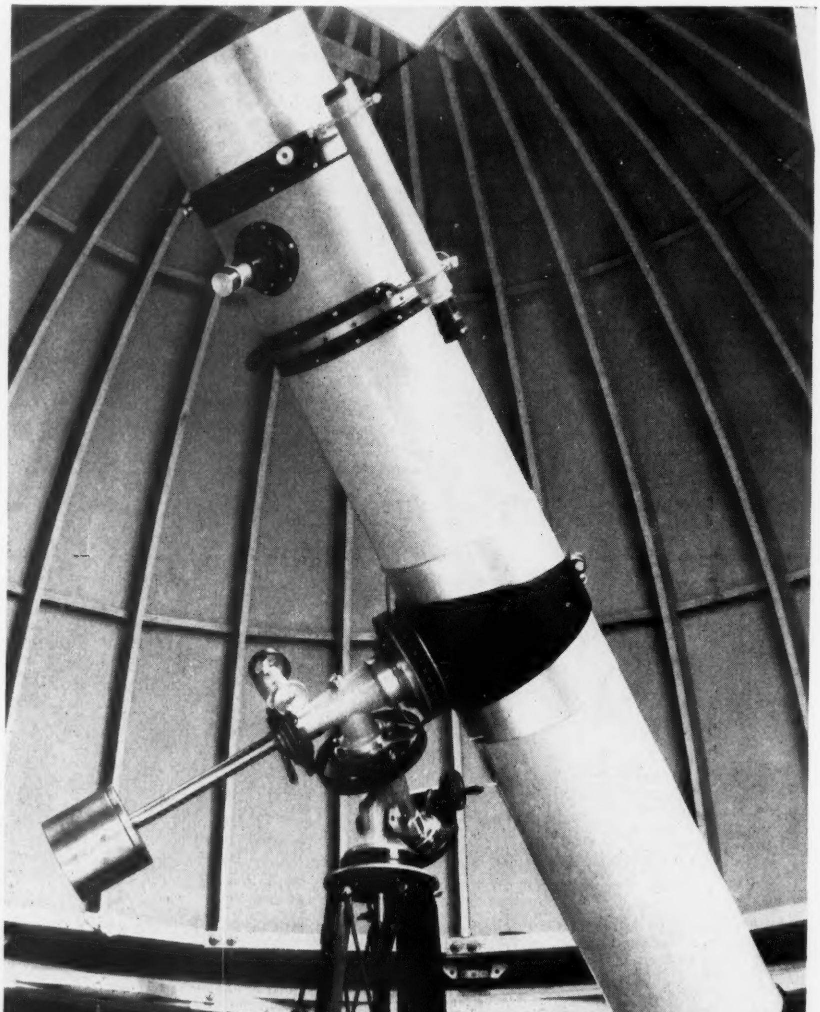
The Fieldston School Observatory

EARLY in 1937, shortly before I became a member of the Optical Division of the Amateur Astronomers Association in New York City, I began designing and building the 8-inch f/8 Newtonian reflector pictured here. It has now been housed in an observatory on the roof of a building at the Fieldston School.

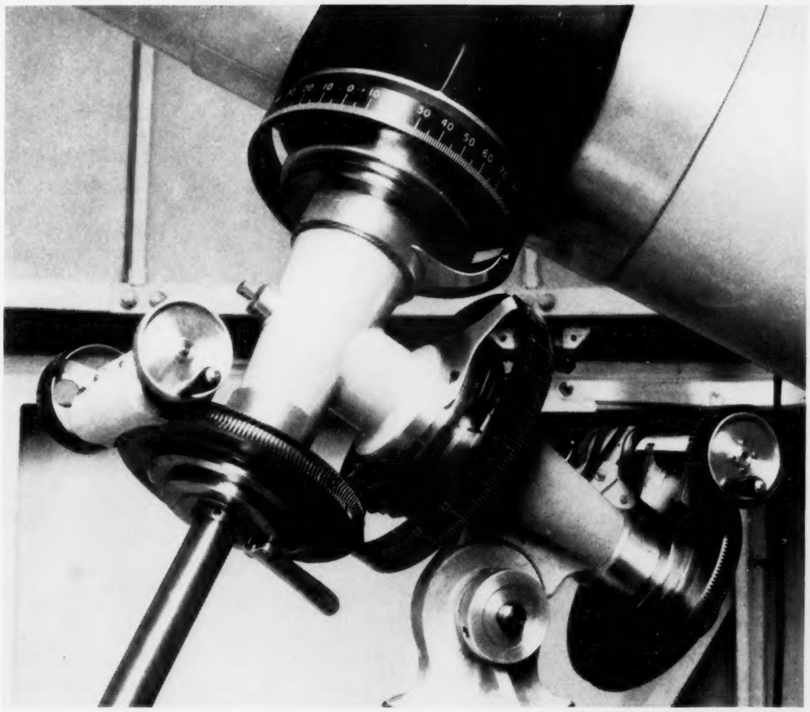
To master the technique of mirror making, I first ground and figured a 6-inch pyrex mirror, followed immediately by an 8-inch, which was figured twice before the results were satisfactory. I obtained enough experience to teach one of the society's mirror making classes. For about eight years I devoted two nights each week to this activity, meanwhile completing the 8-inch reflector in my spare time.

Very few mechanical parts for that instrument were made in the classroom, since I was then employed by a mechanical research laboratory where I occasionally had access to excellent shop equipment. The pictures show some of the specially designed and machined components that make this instrument unusually easy to operate.

The telescope mounting, with a polar axis adjustable for latitude, was originally placed on a strongly braced, three-legged angle-iron tripod, and this same



An interior view of the Fieldston School Observatory, showing the ribbed structure of the dome, and the tube, mounting, and counterweight of the reflector. All photographs with this article are by Alfred L. Copp.

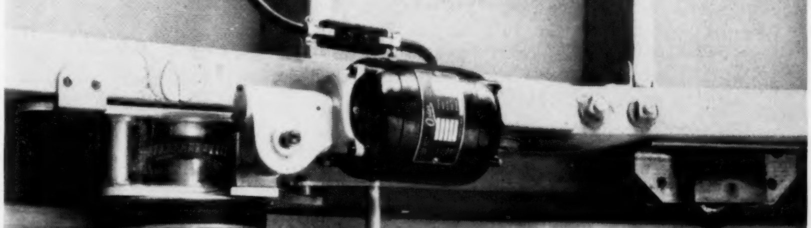


Careful design of the moving parts and fine machining are evident in this closeup of the Kada mounting. The manual drive in right ascension, with graduated drum, is at the right; that for declination is at the left.

unit now serves as its permanent observatory pier, as may be seen in the large picture. The dark tube on the left side of the pier is the control unit for the dome drive.

Observing with a reflector of this size is greatly facilitated if the eyepiece position can be changed according to the part of the sky toward which the instrument is pointing. Most designers provide for rotation of the entire tube, but a better way is to rotate only the upper section that carries the eyepiece assembly and the finder. In my reflector, this upper section turns on a bearing surface below the third black ring (large picture), the rest of the tube being firmly fastened in its cradle. The small handle protruding from the ring below the eyepiece is for leverage in rotating the upper section. For this construction, high precision is required in machining and aligning the mirror's optical axis with the axis of the rotating tube.

The close-up picture of the mounting head shows how the parts fit together to form a smooth-working unit. The declination axis has a slow-motion worm-wheel manual drive, and below this is the clamp for releasing the gear to permit setting the telescope rapidly in declination. The right-ascension worm wheel is driven by a small Hayden timer motor, hidden in the picture behind the polar-axle housing. To enable the observer to point to an object's position with far greater accuracy than by setting circles alone, I have added divided drums to the



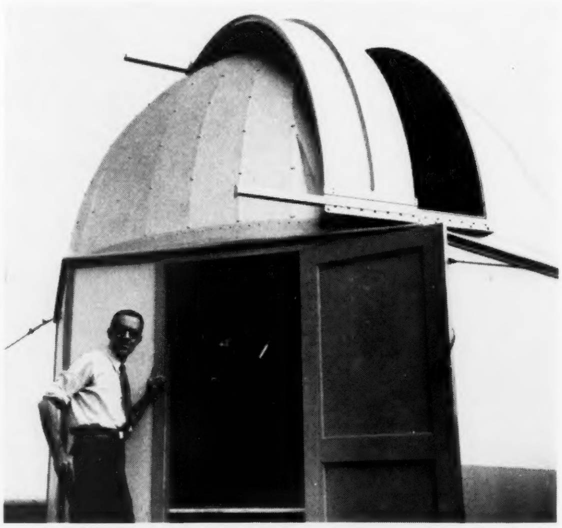
The observatory dome runs on rollers, as seen here at the right. This view also shows the motor and gear train that turn the dome by means of a rubber-tired wheel that presses against the inside of the roller track.

worm shafts of both control gears. These are easier to read than verniers.

I believe an instrument as large as this one should be set up where it can be used by more than one observer. In 1950, through my association with the Ethical Culture Schools, I offered this instrument to them, and discussed the possibility of building an observatory on the roof of one of the buildings of the Fieldston School in upper New York City. One year later, after I had drawn up plans, construction was begun.

Once again, problems of finding time and shop facilities delayed the work, but it is now finished. Although some accessories are still lacking, we have the essentials, such as a sidereal clock, an electric telescope drive, and an electric push-button drive for the dome. We plan to add a synchro-unit to make the dome slit follow the telescope as it tracks a star from east to west across the sky.

GENE KADA
Fieldston School
New York 71, N. Y.



Gene Kada stands alongside the entrance to the Fieldston School Observatory, which is located on the top of one of the institution's buildings, where a good view of the sky can be obtained. The dome shutter slides sideways its full length. Note the heads of the bolts that hold the dome sections to the rib supports, which may be seen in the interior view of the observatory on page 166.

A 12½-inch Fork-Mounted Newtonian-Cassegrainian

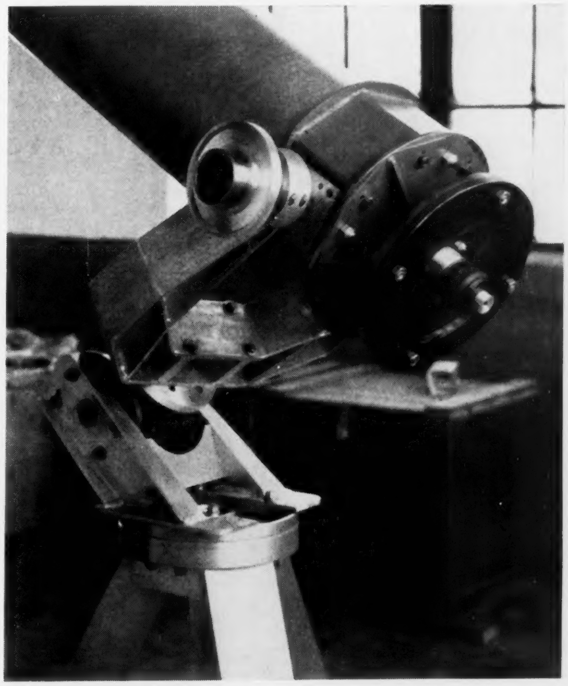
A PORTABLE MOUNTING for a reflector with an aperture as large as 12½ inches must be very sturdy, yet light enough to be carried from place to place. Aluminum parts throughout, except for the steel polar-axis housing, enabled me to design and build the mounting pictured here. Were I to make another such instrument, the polar-axis housing would be of aluminum, too.

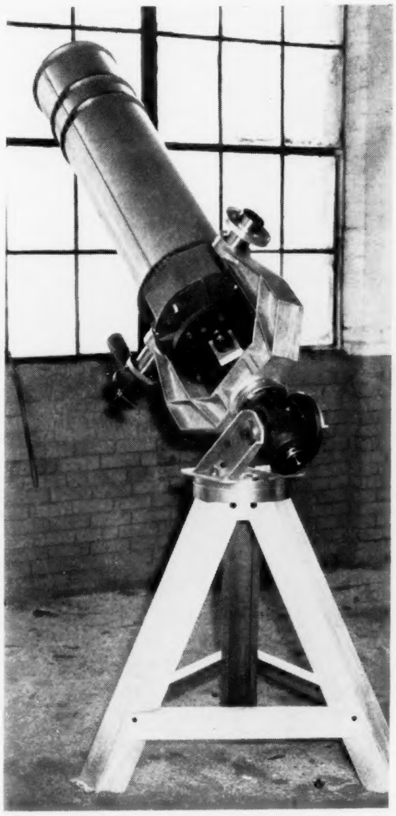
The mounting incorporates provision for latitude adjustment of the polar axis, over a range of 25° to 60°. The instrument was built in Evansville, Indiana, and brought to my present location in Miami, Florida. The optics were made by Rudy Noulik of Cicero, Illinois. The Newtonian diagonal is supported by a four-legged spider at the top of the tube. When observations are to be made at the Cassegrainian focus behind the mirror, a tube containing the convex secondary mirror is screwed over the diagonal, the latter always being left in place.

As the picture below shows, heavy aluminum channel pieces form the tripod legs, extra massive to carry the large telescope without vibration. The horizontal braces are removable so the tripod may be folded for transporting. The tripod top carries two thick disks of metal with clamping bolts in slots to permit aligning the polar axis. A central bolt locks the disks together, but allows the upper one to be rotated horizontally for setting up the instrument.

Two pieces of heavy channel aluminum welded onto flat plates at a 45-degree angle support the polar-axis housing. They are braced by a heavy plate, seen in the second picture to be cut out at its top, allowing the housing's upper end to be lowered to its limit of 25° latitude. The bearings for latitude adjustment were

The portable 12½-inch reflector constructed by Samuel Lutz, a Florida amateur, is seen in these pictures. The view below is from the southwest side of the mounting, with the telescope tube pointed toward the north star, placing its eyepiece between the arms of the fork. Nevertheless, the ocular is made accessible for observing by means of a diagonal. The view at the right is from the northeast side of the mounting, with the tube pointed below the celestial equator. The clock drive, not shown, fastens to the top of the polar axis with screws and dowels.





The Lutz 12½-inch reflector.

welded to the housing. Both pictures show a large metal disk which acts as a brake when its surface is pulled tight against the channel extension. The second picture shows the slots that permit latitude adjustment, with Allen-head bolts locking the unit in place.

Large bearings were required in the polar-axle housing to take the thrust of the heavy mirror, cell, telescope tube, and fork, these together being of considerable weight. At the base of the fork is mounted a worm wheel and setting circle. A driving clock will later be fastened to the top of the housing to engage the worm wheel.

All the parts described so far were fabricated from stock materials that were bent, shaped, and welded. The fork, however, is a casting, and the ribbed structure has eliminated unnecessary weight while retaining rigidity. The second picture shows three of the four bolts that hold the fork to the polar-axis assembly. The upper ends of the fork arms were carefully machined to take the declination-axis bearings.

The mirror housing consists of an octagonal piece of aluminum, with rings of metal welded to the top and bottom. The declination journals are screwed and doweled to opposite faces of the housing. They could have been made all in one piece, but I prefer the doweling method for adjustment purposes.

Similarly, the telescope tube is held by a doweled flange, but the dowels were not put into place until the optical parts were aligned. Being able to shift the tube at this stage greatly helped the alignment process.

A heavy ring of iron is held a short distance behind the mirror cell by four long bolts. This counterbalance brings the center of gravity of the tube into coincidence with the declination axis, balancing the telescope around it.

All the focal positions have large openings to permit the use of low-power wide-field eyepieces. These openings are needed if a camera is to be used for photography. At the Cassegrainian focus behind the mirror, a large diagonal may be attached to direct the light sideways if necessary. The finder is a war-surplus elbow telescope mounted at one end of the declination axis, as seen in the first picture.

SAMUEL LUTZ
573 S.W. 6th St.
Miami, Fla.

"BULLETIN A" AVAILABLE

Hundreds of requests have been received for the 21-page photo-offset pamphlet, "The Schiefspiegler (Oblique Telescope)," by the West German amateur Anton Kutter. As announced on page 66 last month, when Mr. Kutter's lunar photographs were published, *Bulletin A* may be obtained for 25 cents, to cover handling and postage, from Sky Publishing Corporation, Cambridge 38, Mass.

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54 mm. (2⅛")	390 mm. (15.4")	9.75
54 mm. (2⅛")	508 mm. (20")	12.50
54 mm. (2⅛")	600 mm. (23½")	12.50
54 mm. (2⅛")	762 mm. (30")	12.50
54 mm. (2⅛")	1016 mm. (40")	12.50
54 mm. (2⅛")	1270 mm. (50")	12.50
78 mm. (3-1/16")	381 mm. (15")	21.00
80 mm. (3⅛")	495 mm. (19½")	28.00
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Diameter	Focal Length	Each
83 mm. (3¼")	660 mm. (26")	$28.00
83 mm. (3¼")	711 mm. (28")	28.00
83 mm. (3¼")	762 mm. (30")	28.00
83 mm. (3¼")	876 mm. (34½")	28.00
83 mm. (3¼")	1016 mm. (40")	30.00
102 mm. (4")	876 mm. (34½")	60.00
108 mm. (4¼")	914 mm. (36")	60.00
110 mm. (4⅜")*	1069 mm. (42-1/16")	60.00
110 mm. (4⅜")	1069 mm. (42-1/16")	67.00
128 mm. (5-1/16")*	628 mm. (24¾")	75.00
128 mm. (5-1/16")	628 mm. (24¾")	85.00

*Not coated

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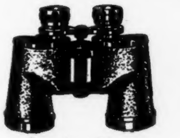
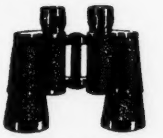

American Type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7 x 35	341	Zeiss	20.75	17.95
7 x 35	341	American	23.50	—
7 x 35	578	American Wide Angle 11°	35.00	—
7 x 50	372	Zeiss	24.95	22.50
7 x 50	372	American	32.50	—
8 x 30	393	Zeiss	21.00	18.25
10 x 50	275	Zeiss	28.75	26.75
20 x 50	183	Zeiss	33.75	31.75

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	Price		Price
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8 x 30	11.25	16 x 50	17.50
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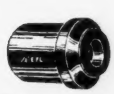

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18 mm. (¾")	Symmetrical	6.00
22 mm. (27/32")	Kellner	6.00
27 mm. (1-1/16")	Kellner	4.50
32 mm. (1¼")	Orthoscopic	12.50
35 mm. (1⅜")	Symmetrical	8.00
55 mm. (2-3/16")	Kellner	6.00
56 mm. (2¼")	Symmetrical	6.00

COATED LENSES 75 cents extra.

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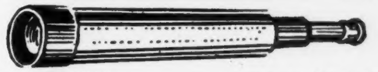

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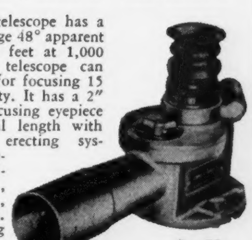
8 x 50

This M-17 telescope has a brilliant-image 48° apparent field — 325 feet at 1,000 yards. The telescope can be adjusted for focusing 15 feet to infinity. It has a 2" objective, focusing eyepiece 28-mm. focal length with an Amici erecting system. Turret-mounted filters: clear, red, amber, and neutral. Lamp housing to illuminate reticle for nighttime use. Truly the biggest bargain you were ever offered. Original Gov't. cost $200.

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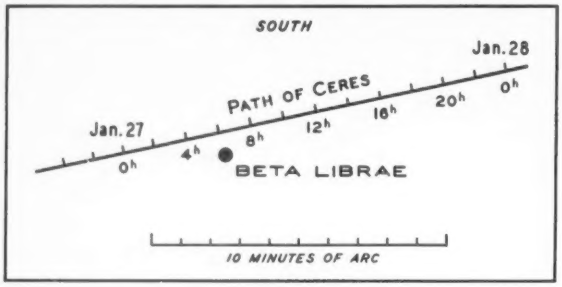
CELESTIAL CALENDAR

Universal time (UT) is used unless otherwise noted.

Ceres and Beta Librae

During the morning hours of Tuesday, January 27th, the minor planet Ceres will pass within a minute of arc south of the 2.7-magnitude star Beta Librae. James Young, Seattle, Washington, points out that this will be an excellent opportunity for amateurs with small telescopes to identify this asteroid.

Closest approach of Ceres to the star will occur at 6:12 Universal time (12:12 a.m. Central standard time) with their separation 59 seconds of arc. However, Beta Librae will then be below the horizon for most American observers, but it will reach an altitude of 10 degrees above the horizon shortly after two o'clock local time. The star and asteroid will appear as a wide, easy double star, magnitudes 2.7 and about 8.2. The separation will gradually increase, Ceres moving 0.7 minute of arc westward per hour, as shown in the diagram.



The path of the asteroid Ceres past Beta Librae on January 27th, plotted in two-hour intervals, from data in the "American Ephemeris." Labels indicate Universal time. South is at the top in this chart, matching the view in an inverting telescope.

MINOR PLANET PREDICTIONS

Vesta will be easy to observe in Cancer during the first five months of this year – a good object for binoculars. Its magnitude will be 6.9 at opposition on January 26th, 7.1 in mid-March, and 7.6 by the end of April. This asteroid thus may be readily identified by plotting the predicted path in the Skalnate Pleso *Atlas of the Heavens*. On January 21st Vesta will pass one degree north of Gamma Cancri, magnitude 4.7.

Vesta, 4, 6.9. January 2, 8:56.4 +20-27; 12, 8:49.0 +21-33; 22, 8:39.2 +22-44. February 1, 8:28.6 +23-51; 11, 8:18.4 +24-47; 21, 8:10.1 +25-29. March 3, 8:04.5 +25-55; 13, 8:02.1 +26-07; 23, 8:03.0 +26-06. April 2, 8:07.0 +25-54; 12, 8:13.7 +25-32; 22, 8:22.8 +25-00. May 2, 8:33.7 +24-20; 12, 8:46.2 +23-31; 22, 8:59.9 +22-34. Opposition on January 26.

Herculina, 532, 8.9. January 22, 9:54.4 +25-20. February 1, 9:48.1 +27-28; 11, 9:40.1 +29-28; 21, 9:31.7 +31-09. March 3, 9:24.3 +32-24; 13, 9:18.9 +33-09. Opposition on February 12.

Hebe, 6, 9.1. January 22, 10:21.9 +11-26. February 1, 10:15.0 +13-02; 11, 10:06.5 +14-46; 21, 9:57.2 +16-28. March 3, 9:48.5 +18-01; 13, 9:41.1 +19-16. Opposition on February 17.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0^h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

JANUARY METEORS

The last-quarter moon will interfere little with observations of the Quadrantid meteor shower. The duration of this shower is one day or less, and peak activity this year will occur during daylight hours on January 3rd for American observers. Under favorable conditions in previous years, 35 meteors per hour have been counted at the height of the shower. The radiant is in northern Bootes, at right ascension 15^h 20^m, declination +50°.

W. H. G.

VARIABLE STAR MAXIMA

January 1, R Andromedae, 001838, 7.0; 1, S Hydrae, 084803, 7.9; 1, RT Sagittarii, 2011**39**, 7.9; 1, S Sculptoris, 0010**32**, 6.8; 2, R Hydrae, 1324**22**, 4.6; 6, R Aquarii, 2038**15**, 7.3; 8, S Carinae, 1006**61**, 5.7; 12, V Monocerotis, 0617**02**, 7.1; 13, RS Herculis, 171723, 8.0; 21, R Horologii, 0250**50**, 6.0; 23, W Lyrae, 181136, 8.0; 28, RT Cygni, 194048, 7.4; 31, S Pavonis, 1946**59**, 7.3.

February 4, RU Sagittarii, 1951**42**, 7.2.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

UNIVERSAL TIME (UT)

TIMES used in Celestial Calendar are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown.

OCCULTATION PREDICTIONS

January 19-20 **Delta Tauri** 3.9, 4:20.6 +17-26.9, 11. Im: **F** 8:02.7 –1.1 +1.2 39; **H** 7:36.4 –1.9 +1.5 41.

January 19-20 **64 Tauri** 4.8, 4:21.7 +17-21.0, 11. Im: **E** 8:38.1 ..... 18; **F** 8:28.9 –0.4 –0.3 67; **H** 8:08.4 –1.3 –0.4 70.

For stations in the United States and Canada, usually for stars of magnitude 5.0 or brighter, data from the *American Ephemeris* and the *British Nautical Almanac* are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard-station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo–LoS**), and multiply **b** by the difference in latitude (**L–LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A	+72°.5,	+42°.5	**E**	+91°.0,	+40°.0
B	+73°.6,	+45°.5	**F**	+98°.0,	+31°.0
C	+77°.1,	+38°.9	**G**	Discontinued	
D	+79°.4,	+43°.7	**H**	+120°.0,	+36°.0
			I	+123°.1,	+49°.5

MINIMA OF ALGOL

January 3, 15:37; 6, 12:26; 9, 9:16; 12, 6:05; 15, 2:54; 17, 23:44; 20, 20:33; 23, 17:22; 26, 14:11; 29, 11:00.

February 1, 7:50; 4, 4:39; 7, 1:28; 9, 22:18.

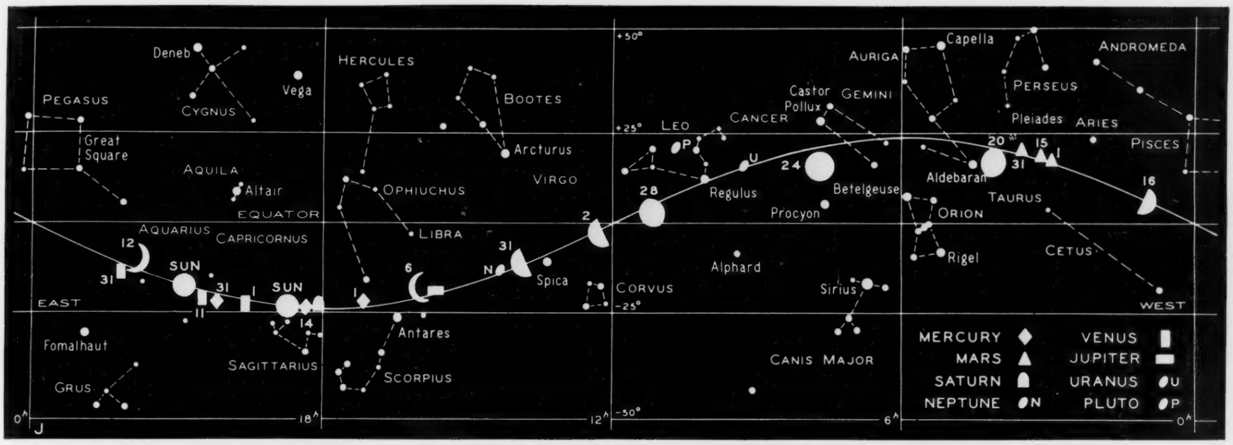
These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

Because the period of Algol is changing, new observations of the times when this star is at minimum brightness are very desirable, in order to improve the ephemeris. Amateurs are invited to report their results to Sky and Telescope. The method of observation and reduction is explained on pages 190-192 of the February, 1957, issue.

MOON PHASES AND DISTANCE

Last quarter	January	2, 10:50
New moon	January	9, 5:34
First quarter	January	16, 21:26
Full moon	January	24, 19:32
Last quarter	January	31, 19:06
New moon	February	7, 19:22

January	**Distance**	**Diameter**
Perigee 5, 20^h	228,100 mi.	32′ 33″
Apogee 17, 17^h	251,200 mi.	29′ 33″
Perigee 31, 6^h	230,100 mi.	32′ 16″
February		
Apogee 14, 14^h	251,300 mi.	29′ 33″



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other days shown. All positions are for 0^h Universal time on the respective dates.

Mercury is visible at the beginning of January low in the southeast, where it rises about $1\frac{1}{2}$ hours before the sun and is of magnitude -0.2. It may be seen for the first two weeks of the month as it moves slowly back toward the sun, finally becoming lost in the glare of dawn.

Venus is a brilliant object in evening twilight, low in the southwest, setting about an hour after the sun. During January it moves from Sagittarius across Capricornus into Aquarius. Venus' magnitude remains about -3.4 all month.

Mars continues to be conspicuous in the evening sky, at magnitude -0.2. At midmonth it is in eastern Aries, and transits about $2\frac{1}{2}$ hours after sunset. As the earth's distance from Mars increases, the latter's apparent disk shrinks from 13″ in diameter on January 1st to 9″ on the 31st. The moon will pass close to Mars on the evening of the 18th, with the planet about 5° north when closest.

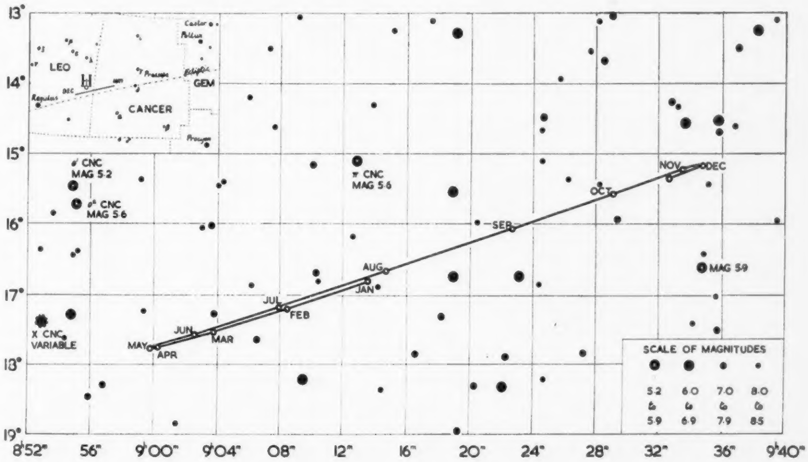
Jupiter is a morning object in Libra, rising about four hours before the sun on January 15th, and at magnitude -1.4. Telescopically, the planet presents a slightly flattened disk 33″.6 in equatorial diameter and 31″.4 in polar diameter. The moon will pass about 2° north of Jupiter on the morning of the 5th.

Saturn is in Sagittarius, rising in the southeast about $1\frac{1}{2}$ hours before the sun in the middle of the month, its magnitude being $+0.7$. There will be a close conjunction of Saturn and Mercury at 4:00 UT on January 11th. When the pair rises several hours later for American observers, they will be less than a degree apart and best seen with binoculars.

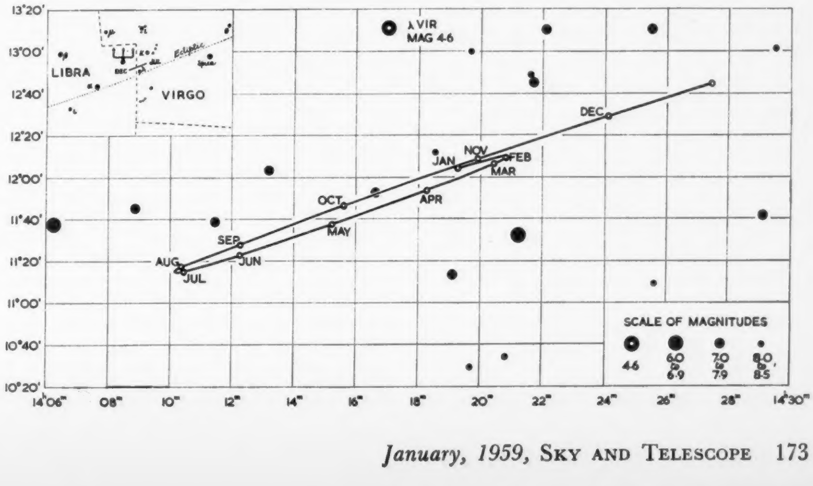
Uranus is in Cancer, rising about two hours after sunset and still in retrograde motion. Binoculars are usually necessary to show this 6th-magnitude object. On January 15th, Uranus will be at right ascension $9^h\ 10^m.8$, declination $+17°\ 00'$ (1950 co-ordinates).

Neptune is an 8th-magnitude object in Libra, at right ascension $14^h\ 19^m.7$, declination $-12°\ 06'$ (1950) on the 15th of the month, when it rises about midnight, local time. The planet will reach western quadrature on January 27th. The moon will make two very close approaches to Neptune this month, on the 4th and 31st. Occultations of the planet will be visible in Africa on the first date, and in parts of the southern United States, in Central and South America on the second of these two occasions.

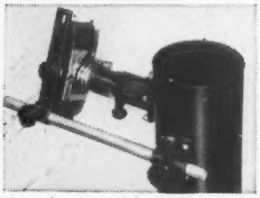
W. H. G.



The path of Uranus among the stars of Cancer and Leo is shown above; that for Neptune among the stars in Virgo and Libra, below. In each case the field is inverted, with south at the top. (The insets have north at the top.) The scales of the two charts are not the same. From the 1959 "Handbook" of the British Astronomical Association, courtesy J. G. Porter, editor.



Take Pictures Through Your Telescope with the EDMUND CAMERA HOLDER for TELESCOPES



Bracket attaches permanently to your reflecting or refracting telescope. Removable rod with adjustable bracket holds your camera over scope's eyepiece and you're ready to take exciting pictures of the moon. You can also take terrestrial telephoto shots of distant objects. Opens up new fields of picture taking!

SUN PROJECTION SCREEN INCLUDED

White metal screen is easily attached to holder and placed behind eyepiece. Point scope at sun, move screen to focus . . . and you can see sunspots!

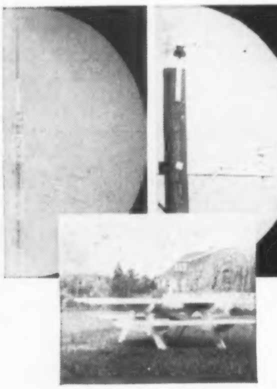
All for the low, low price of $9.95

Includes brackets, 28¾" rod, projection screen, screws, and directions. Aluminum . . . brackets black crinkle painted.

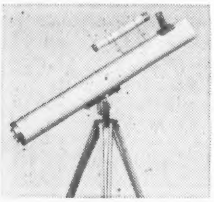
Stock #70,162-Y....................................$9.95 ppd.

Send check or money order — Money-back guarantee.

CAMERA HOLDER ABOVE WILL AFFORD SHOTS LIKE THESE!



These untouched photos show bottom view taken with regular camera. Also ones taken with our #127-size-roll-film telescope camera on our 4¼" reflecting telescope. The telephone pole seen in right-hand picture is 300 yards away. TV antenna at left is about 4 miles away.



3-inch Astronomical Reflector

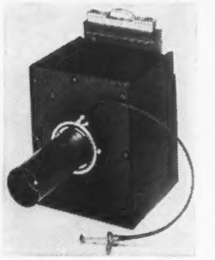
60 to 160 Power
An Unusual Buy!

Assembled — ready to use! See Saturn's rings, the planet Mars, huge craters on the moon, star clusters, moons of Jupiter, double stars, nebulae, and galaxies! Equatorial-type mounting with locks on both axes. Aluminized and over-coated 3"-diameter f/10 primary mirror, ventilated cell. Telescope comes equipped with a 60X eyepiece and a mounted Barlow lens, giving you 60 to 160 power. A finder telescope, always so essential, included. Sturdy, hardwood, portable tripod.

Free with scope: Valuable STAR CHART and 272-page ASTRONOMY BOOK.

Stock #85,050-Y..................................$29.95 ppd.

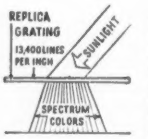
TELESCOPE CAMERA



Here is a special camera for taking excellent closeup shots through your telescope — pictures of the moon, stars . . . terrestrial telephoto pictures. Sturdily built, easily operated, this useful camera employs sheet film. One filmholder, size 2¼" x 3¼", is included. Camera lens is 4-element — not only magnifies the image but extends it from normal eyepiece image plane to film plane. Yellow filter included. Camera box size is 3" x 4" x 5". Tube that fits into eyepiece holder is 5" long with 1¼" O.D. for standard telescopes. Cable release and 3¼"-x-4½" piece of ground glass for focusing also included. Precision German-made shutter has settings for Time, Bulb, 1, ½, 1/5, 1/10, 1/25, 1/100, and 1/200 second. Also has delayed-action shutter release.

Stock #70,166-Y.................................$39.50 ppd.

REPLICA GRATING Low, Low Cost



It's here — after decades of effort! Replica grating — on film — at very low price. Breaks up white light into full spectrum colors. An exciting display. 13,400 lines per inch, running long way on film 8" wide — grating area 7½". Thickness about 0.005". Dispersion about 24° in 1st order. Use it for making spectroscopes, for experiments, as a fascinating novelty. First time available in such a large size — so cheaply. Comes in clear-plastic protector.

Stock #50,202-Y....Includes 2 pieces, 8" x 5½" — 1 transmission type, 1 reflection type....**$2.00 ppd.**
Stock #50,180-Y....1 piece, transmission type, 8" x 6'....................................**$5.95 ppd.**
Stock #50,203-Y....1 piece, reflection type, 8" x 6' **$10.95 ppd.**

Mounted Ramsden Eyepieces

Standard 1¼" Diameter

Our economy model, standard-size (1¼" O.D.) eyepiece. We mounted two excellent quality plano-convex lenses in black anodized aluminum barrels instead of chrome-plated brass to save you money. The clear image you get with these will surprise you. Directions for using short focal length eyepieces are included with both the ¼" and ½" models.

Stock #30,204-Y....¼" focal length....$4.75 ppd.
Stock #30,203-Y....½" focal length....$4.50 ppd.

OBSERVE SUNSPOTS

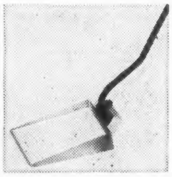
Reduce intensity of the sun's rays, by using a Herschel wedge plus a sun filter over the eyepiece.

UNMOUNTED HERSCHEL WEDGE

Size, 40 mm. x 55 mm.; wedge angle is 10°. The critical surface is flat to ¼ wave. Not mounted.

Stock #30,265-Y..$3.50

MOUNTED HERSCHEL WEDGE



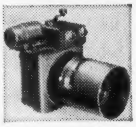
Same size as above but mounted with diagonal holder for reflectors. Fits our rack-and-pinion holder, Stock No. 50,077-Y, that is also used on our 4¼" and 6" reflectors. Holder rod is long enough for 4¼", 6", and 8" mirrors. Rod is 5/32" diameter and 5" long.

Stock #30,266-Y....$5.50

INVITATION

VISIT OUR RETAIL STORE — (10 miles from Philadelphia — two miles from Exit #3 of the New Jersey Turnpike). When you're near us, stop in and see our big display. Our store contains many miscellaneous items at bargain prices.

K-24 AERIAL CAMERA



War surplus — guaranteed perfect working order. Excellent camera for photographing satellites. Complete with 7" f/2.5 Kodak Aero Ektar lens and magazine which takes film 5½" wide x 26' long.

Stock #85,067-Y.................$99.50 f.o.b. Utah

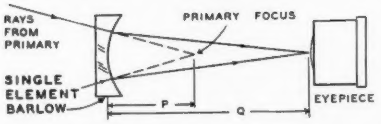
AERIAL CAMERA LENS

f/2.5 with 7" Focal Length

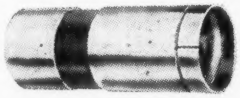
An excellent lens — can be adapted for use on 35-mm. and Speed Graphic cameras as a telephoto lens. Three of the first four pictures of Sputnik III were taken by a student with a homemade camera using one of these lenses. Adjustable diaphragm, f/16 to f/2.5. Gov't. cost over $400. War surplus.

Stock #70,161-Y.........................$39.95 ppd.

DOUBLE AND TRIPLE YOUR TELESCOPE'S POWER WITH A BARLOW LENS



WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q.



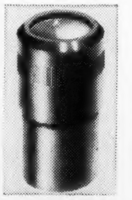
Beautiful chrome mount. We now have our Barlow lens mounted in chrome-plated brass tubing with special spacer rings that enable you to vary easily the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted lens into your 1¼" I.D. tubing, then slide your 1¼" O.D. eyepieces into our chrome-plated tubing. Two pieces provided, one for regular focal length eyepieces and one for short focal length ones.

Remember, in addition to doubling and tripling your power, a Barlow lens increases your eye relief and makes using a short focal length eyepiece easier.

Don't fail to try one of these. Many people do not realize the many advantages of a Barlow and the much greater use they can get from their telescopes. Our Barlow has a focal length of −1-5/16". We have received many complimentary letters about this lens. So sure are we that you will like it that we sell it under a 30-day guarantee of satisfaction or your full purchase price returned — no questions asked. You can't lose, so order today.

Stock #30,200-Y Mounted Barlow lens......$8.00 ppd.

WAR-SURPLUS TELESCOPE EYEPIECE

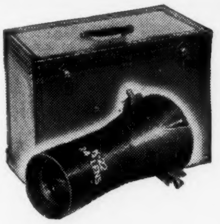


Mounted Kellner Eyepiece, Type 3. 2 achromats, focal length 28 mm., eye relief 22 mm. An extension added, O.D. 1¼", standard for most types of telescopes. Gov't. cost $26.50.

Stock #5223-Y......$7.95 ppd.

EDMUND SCIENTIFIC CO.

SALE! Terrific WAR-SURPLUS BARGAIN! Made by B. & L. and E. K.



AERIAL CAMERA LENSES

Gov't. Cost $1218
Our Price, $39.50
Used; $59.50 New

24" f.l., f/6, in 23"-long lens cone

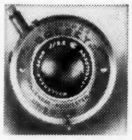
Mounted in beautiful brass cells, lenses are 4"-diam. precision 4-element type, Aero Tessar and Aero Ektar. Housed in cone — focal plane 10" beyond cone and permits building on a filmholder, eyepiece, etc. Lenses are easily removed for other uses. Diaphragm included — adjusts by flexible rod (easily extended) from f/6 to f/22. Opens approx. 1" to 3½". Lens and cone weigh 25 lbs. Sturdy carrying trunk weighs 26 lbs.

USES: 1. For long-range, Big Bertha telephoto lens. 2. For rich-field (wide-field, low-power) telescope. 3. As opaque projector lens. 4. In Operation Phototrack (photographing artificial satellites).

Stock #85,059-Y............24", used............$39.50 f.o.b. Utah
Stock #85,060-Y............24", new............$59.50 f.o.b. Utah

Send check or money order — Money-back guarantee.

ANASTIGMAT 35-MM. CAMERA LENS AND SHUTTER



f/3.2, 44-mm. focal length. A $24.00 value. American made for high-quality 35-mm. camera. Brand new. Lenses low-reflection coated. For color or black and white. Shutter speeds: Time, Bulb, 200, 100, 50, 25, 10. Iris diaphragm f/3.2 to f/22.

Stock #30,311-Y
Synchronized for flash.....$9.50
Stock #30,312-Y.......Not synchronized........$8.50

EQUATORIAL MOUNT and TRIPOD with CLOCK DRIVE

Heavy-duty mount. Drive operates on 110-volt, 60-cycle, a.c. house current. Follows motion of stars smoothly. 32" tripod legs included.

Stock #85,081-Y.....$76.50 f.o.b. Barrington, N. J.

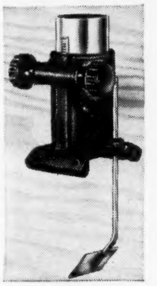
Same mount as above, without clock drive, for 8" or smaller reflectors and for 4" or smaller refractors.

Stock #85,023-Y.....New Low Price.....$39.50 f.o.b. Barrington, N. J.

MOTORIZED CLOCK DRIVE (by itself) easily attached to your own mount. Instructions included.

Stock #50,198-Y........................$36.95 ppd.

Rack & Pinion Eyepiece Mounts



Real rack-and-pinion focusing with variable tension adjustment; tube accommodates standard 1¼" eyepieces and accessory equipment; lightweight aluminum body casting (not cast iron); focusing tube and rack of chrome-plated brass; body finished in black wrinkle paint. No. 50,077-Y is for reflecting telescopes, has focus travel of over 2", and is made to fit any diameter or type tubing by attaching through small holes in the base. Nos. 50,103-Y and 50,108-Y are for refractors and have focus travel of over 4". Will fit our 2⅞" I.D. and our 3⅞" I.D. aluminum tubes respectively.

For Reflectors

Stock #50,077-Y (less diagonal holder) $8.50 ppd.
Stock #60,049-Y (diagonal holder only) 1.00 ppd.

For Refractors

Stock #50,103-Y (for 2⅞" I.D. tubing) 12.95 ppd.
Stock #50,108-Y (for 3⅞" I.D. tubing) 13.95 ppd.

5" DIAM. TELESCOPE OBJECTIVE AIR-SPACED ACHROMAT

Coated 4 surfaces. Focal length 71", f/14.2. Effective aperture 4.73", f/15.

Stock #70,163-Y...Unmounted...........$125.00 ppd.
Stock #70,164-Y...Mounted in cell (Inside diam. 5"; outside diam. 5½" with 6½" flange) with adapter to fit 6⅞" I.D. tubing..........$150.00 ppd.

"MAKE-YOUR-OWN" 4¼" MIRROR KIT

The same fine mirror as used in our telescopes, polished and aluminized, lenses for eyepieces, and diagonal. No metal parts.

Stock #50,074-Y................................$16.25 ppd.

8-POWER ELBOW TELESCOPE

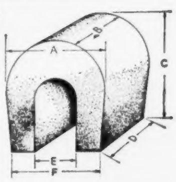
War Surplus
$200 Value for Only $13.50

Big 2" objective, focusing eyepiece 28-mm. focal length, Amici erecting system, turret-mounted filters of clear, red, amber, and neutral, reticle illumination. Sparkling, clear, bright image — 6° field (325 ft. at 1,000 yards). Focus adjusts 15 ft. to infinity. Eyepiece alone, 28-mm. focal length, is worth more than $12.50.

Stock #70,173-Y.......................$13.50 ppd.

GIANT MAGNET

War Surplus — Below Cost



Real giant, 15¾ lbs. Alnico V Magnetron type. Was used in Magnetron tubes. Horseshoe shape. Approx. 5,000-6,000 Gauss rating. Will lift about 250 lbs. Dimensions: A — 5-3/16", B — 3¾", C — 5½", D — 2½", E — 2⅛", F — 4⅜" (see illustration).

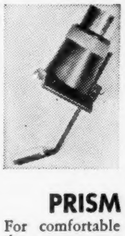
Stock #85,088-Y $22.50 f.o.b. Barrington, N. J.

Shipping wt. 22 lbs.

MAGNETRON TUBE (probably not in working order) with two of magnets above.

Stock #85,059-Y..........................$39.50 f.o.b.
Shipping wt. about 70 lbs. Barrington, N. J.

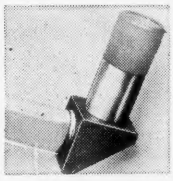
STANDARD 1¼" EYEPIECE HOLDER



Here is an economical plastic slide-focus eyepiece holder for 1¼" O.D. eyepieces. Unit includes 3"-long chrome-plated tube into which your eyepiece fits for focusing. Diagonal holder in illustration is extra and is not included.

Stock #60,067-Y.........$2.50 ppd.

PRISM STAR DIAGONAL



For comfortable viewing of the stars near the zenith or high overhead with refracting telescopes using standard size (1¼" O.D.) eyepieces, or you can make an adapter for substandard refractors. Contains an excellent quality aluminized right-angle prism. Tubes are satin chrome-plated brass. Body is black wrinkle cast aluminum. Optical path of the system is about 3½".

Stock #70,077-Y.................................$12.00 ppd.

"TIME IN ASTRONOMY" BOOKLET

By Sam Brown. All about various kinds of time, contains sidereal timetable. How to use single- and double-index setting circles, how to adjust an equatorial mount, list of sky objects. Also includes 7" paper setting circles and stripes suitable for cutting out and mounting on plywood. Wonderfully illustrated.

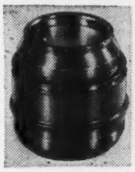
Stock #9054-Y............................60c ppd.

OTHER USEFUL BOOKLETS

"OBSERVING THE SUN"
Stock #9056-Y............................15c ppd.

"TELESCOPE FINDERS"
Stock #9051-Y............................15c ppd.

Sale! GIANT ERFLE EYEPIECE



Here is an exciting bargain. We just bought a large lot of these eyepieces reasonably — so down goes the price to $9.95 for a real sale. Lens system contains 3 coated achromats over 2" in diameter. Gov't. cost over $100.00. Brand new, weight 2 pounds. The value will double when this sale is over, and triple and quadruple as years pass. If we didn't owe the bank so much money, we'd be tempted to hold onto these eyepieces. Their wide apparent field is 65°. The focal length is 1½". Lenses are in a metal cell with spiral threads; focusing adapter with 32 threads per inch is included; diameter is 2-11/16". If you don't order now and you miss out on a hundred-dollar eyepiece for only $9.95, you can't say that we didn't try to impress you with its value. You can make some super-duper finders with these eyepieces. They are also ideal for rich-field telescopes, which are becoming more popular daily, particularly in the Sputnik age. Everyone with a large reflecting telescope should have one of these.

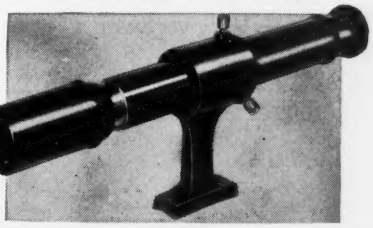
Stock #50,178-Y.................Sale Price $9.95 ppd.

3X ELBOW TELESCOPE

Sometimes the war-surplus end of this business is heartbreaking. Here is an excellent little telescope that cost Uncle Sam about $200.00. Makes a dandy finder with a 13° field. Weight 2 pounds, size 5¾" x 4½". Although our price has been only $7.50 postpaid, they just sit on our shelves year after year. Then to get an item we really wanted, we had to buy 200 more of these telescopes recently. Objective lens is an achromat, diameter 26 mm., focal length 104 mm. Amici roof prism with faces of 18 mm. x 20 mm. cost from $12.00 to $36.00 to make. Symmetrical eyepiece of 1¼" (32.5 mm.) effective focal length consists of 2 achromats with diameters of 34 mm. and focal lengths of 65 mm. At our new price we cannot afford to have our instrument man take these apart and clean them — so we told him to look them over to make sure everything is okay, and now you can buy them for only $5.00 each delivered to you.

Stock #50,179-Y...................................$5.00 ppd.

6X FINDER TELESCOPE



Has crosshairs for exact locating. You focus by sliding objective mount in and out. Base fits any diameter tube — an important advantage. Has 3 centering screws for aligning with main telescope. 20-mm.-diameter objective. Weighs less than ½ pound.

Stock #50,121-Y...................................$8.00 ppd.

MIRROR STAR DIAGONAL

For comfortably viewing astronomical objects with refracting telescopes — also excellent with finders on reflecting telescopes. Can be used on standard microscopes as it is correct size. Eyepiece end takes oculars with 0.917" O.D. and objective end fits into tubes with 0.917" I.D. Made of fine plastic, and contains a first-surface mirror.

Stock #30,278-Y......$3.00 ppd.

7X FINDER TELESCOPE–ACHROMATIC

Stock #50,080-Y Finder alone, less ring mounts...$9.95
Stock #50,075-Y Ring mounts per pair..........$3.95

BE SURE TO GET FREE CATALOG "Y"

Fantastic variety — never before have so many lenses, prisms, optical instruments, and components been offered from one source. Positively the greatest assembly of bargains in all America. Imported! War Surplus! Hundreds of other hard-to-get optical items. Write for Free Catalog "Y."

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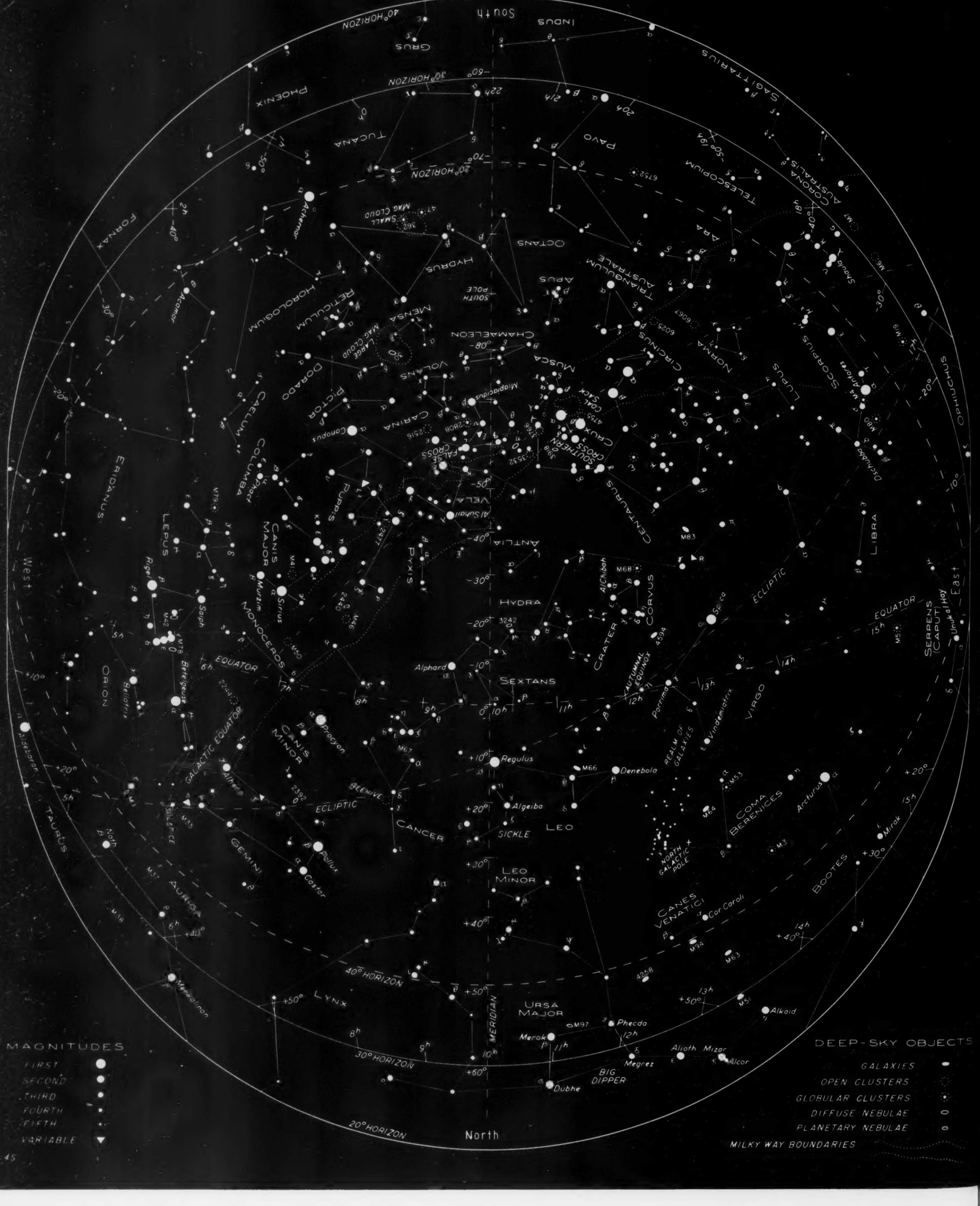
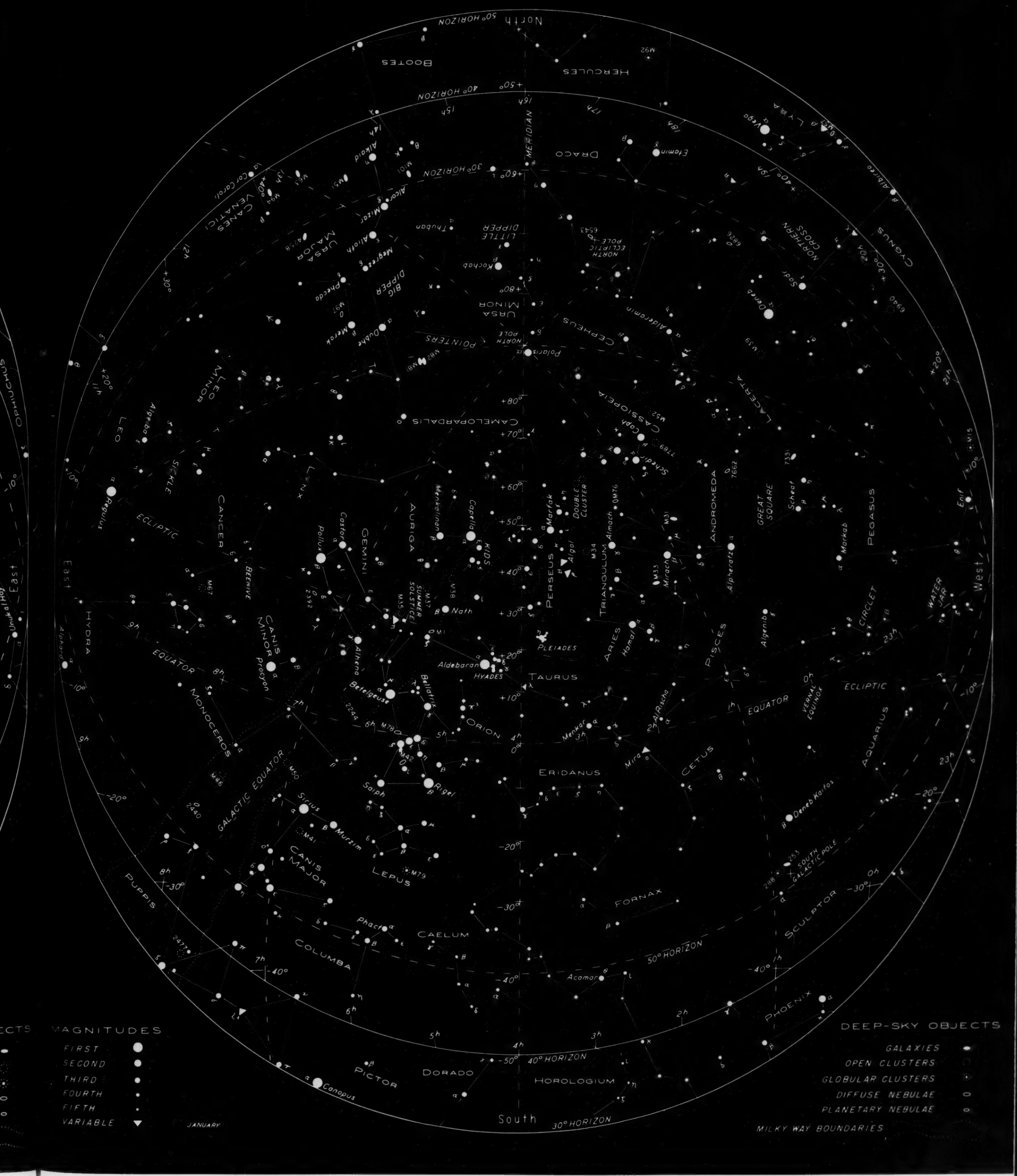


SOUTHERN STARS

The sky as seen from latitudes 20° to 40° south, at 11 p.m. and 10 p.m., local time, on the 7th and 23rd of March, respectively; also, at 9 p.m. and 8 p.m. on April 7th and 23rd. For other dates, add or subtract ½ hour per week.

A rich part of the southern Milky Way, extending from Carina to Crux, is high above the south celestial pole. Close to the Southern Cross, however, is a patch that seems black against the bright lane of starlight. It is the famous Coal Sack, a large dark obscuring nebulosity.



STARS FOR JANUARY

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 6th and 21st of January, respectively; also at 7 p.m. and 6 p.m. on February 6th and 21st. For other dates, add or subtract ½ hour per week.

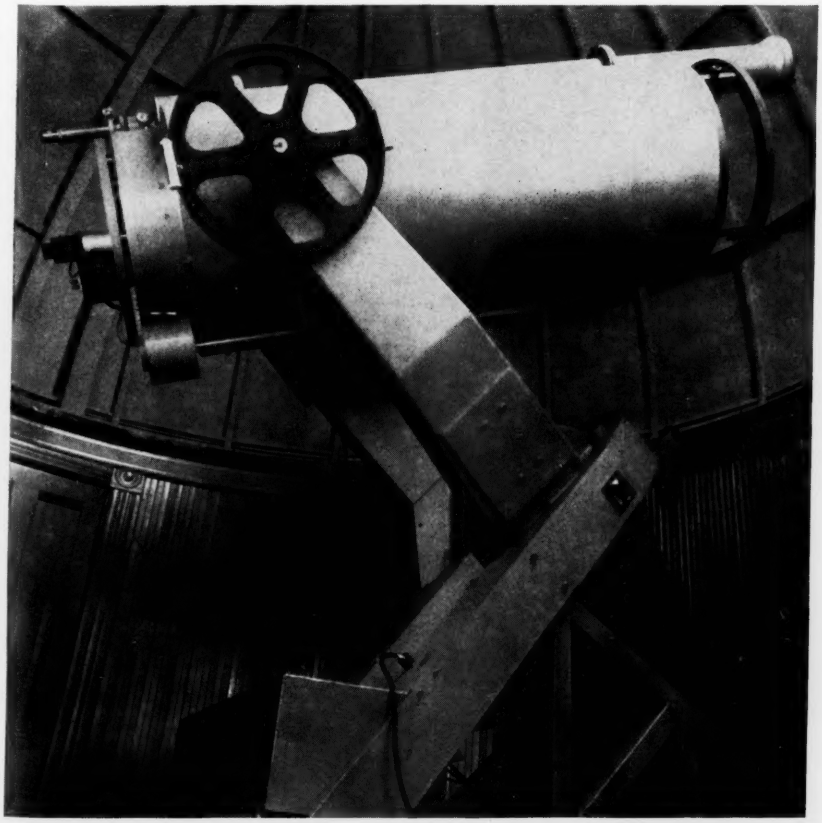
To match ordinary standard time to the time of this chart, the difference between the observer's longitude and the standard-time meridian must be applied. The table of time differences on page 149 of this issue gives corrections for some principal cities in the United States.

PRECISION ENGINEERING AND DESIGN

by two famous astronomical manufacturers

Above: A standard, motor-driven Astro-Dome constructed of structural steel.

Below: A typical Tinsley telescope built to meet professional observing requirements.



The technical skill of Astro-Dome, Inc., and Tinsley Laboratories guarantees the highest standards of precision in observatory domes and telescopes.

ASTRO-DOME is proud to have been selected to design and build the domes at the University of Wisconsin's beautiful Pine Bluff Observatory. As a visitor to the observatory travels over the rolling hills of southern Wisconsin, he first catches the gleam of sunlight from the domes of the 36-inch reflector and the 12-inch reflector (pictured here). On arriving at the site he is immediately impressed by the combination of flowing beauty in metal and great structural stability that are features of all Astro-Domes. But only by using these domes for routine observation, night after night, can one really become aware of the ease of operation and the long-wearing qualities of our design. We are now in the process of refining these designs even further to make our domes the best available anywhere. May we assist you with your observatory housing problems, too?

TINSLEY LABORATORIES has engineered the 20-inch fork-mounted Newtonian-Cassegrainian reflector pictured here for the Students' Observatory at the University of California. Note the clean functional design of the mounting, planned for efficient observing. The optics are of Tinsley precision, all surfaces polished to 1/10-wave accuracy. Small and large telescopes of any design are available to your exacting specifications — you are invited to request information of any kind that would be useful to you.

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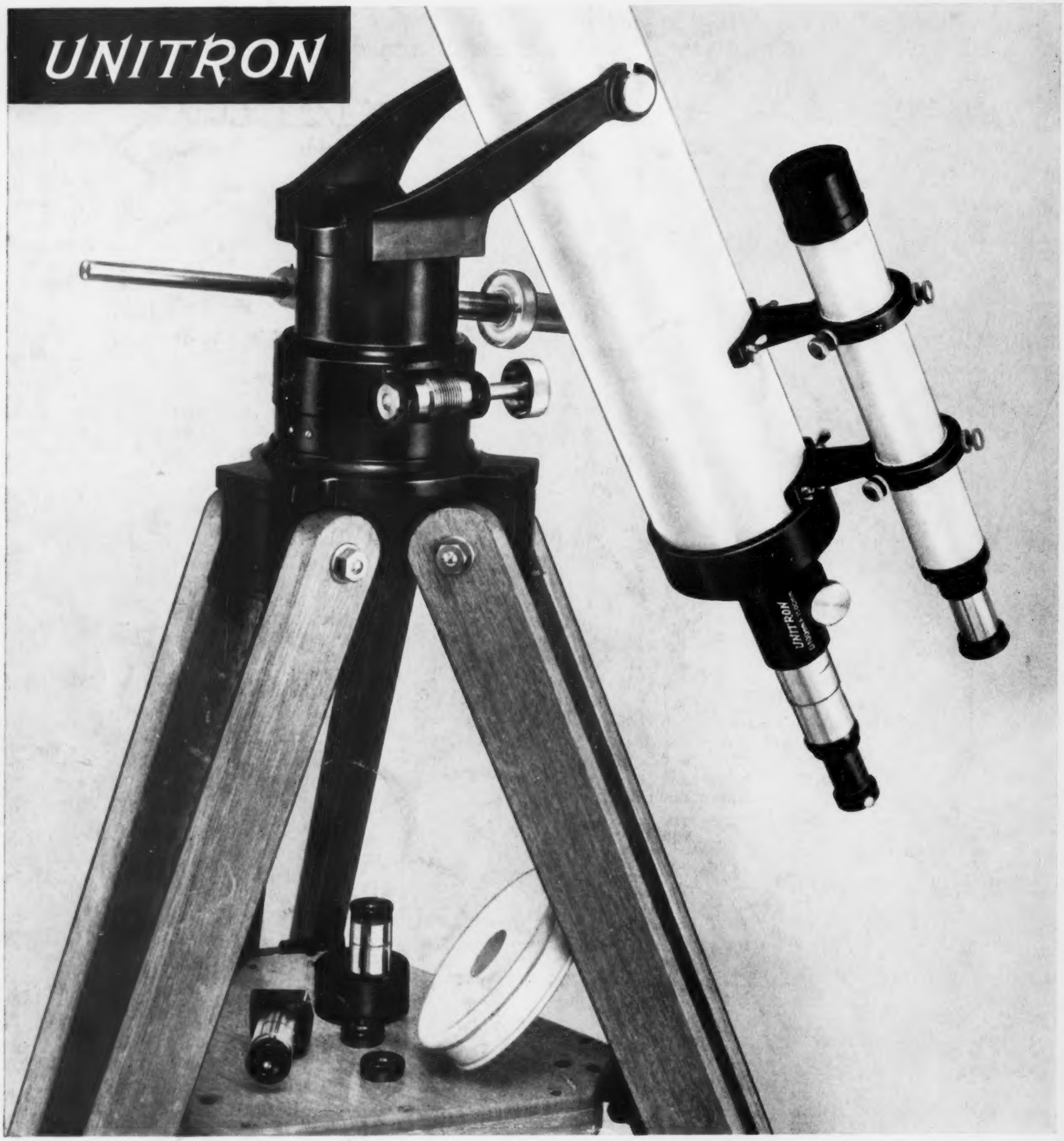

UNITRON's 4" Altazimuth Refractor

Here is the logical choice where requirements call for a large instrument and where budgets will not permit the purchase of a more expensive equatorial model. The UNITRON 4" Altazimuth Refractor, Model 150, is an ideal basic instrument to own. You can always add the equatorial mounting and clock drive, camera, photographic guide telescope, fixed pier, and other accessories.

The rock-sturdy altazimuth mounting is equipped with slow-motion controls and clamps for both altitude and azimuth. The 360° azimuth slow motion features a worm-gear mechanism. This complete refractor includes tripod and mounting, shelf for accessories, large 10x 42-mm. view finder, choice of UNIHEX Rotary Eyepiece Selector or star diagonal and erecting prism system, sunglass, solar aperture diaphragm, cabinets, and eyepieces for 250x, 214x, 167x, 120x, 83x and 60x. The UNITRON 4" Altazimuth Refractor is $465.00 complete. Put yourself at the controls for only $46.50 down.

See pages 164 and 165.

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